



The Blast Furnace and Steel Plant

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The Blast Furnace ^{and} Steel Plant

VOL. VIII.

PITTSBURGH, PA., MAY, 1920.

No. 5.

Design of Experimental Rolling Mill

Description of the Details of the Design of the Experimental Mill of the Bureau of Rolling Mill Research—Power Recording Instruments—Requirements of Mill—Motor and Reduction Gears.

By W. B. SKINKLE.

Director, Bureau of Rolling Mill Research.

PART I.

THIS series of articles dealing with the problems and designs of the experimental rolling mill which the Carnegie Institute of Technology is planning to install, will be an enlargement and intermingling of two papers which were presented by Prof. W. Trinks, head of the Department of Mechanical Engineering at the Carnegie Institute of Technology, and the author, before the Engineers' Society of Western Pennsylvania, on April 20.

The designs of the mill will be taken up in detail and the reasons for many of special features will be explained. A number of the problems which designers and operators of rolling mills are facing will be discussed and the ways and means for studying these problems and making accurate observations of the rolling phenomena will be explained.

The inability of engineers to exercise accurate control over the many variables entering into the rolling and forging of steel and other metals, makes it almost impossible to make anything approaching accurate observations on commercial rolling mills which are built for production of large tonnages and are not expected to be turned into scientific "playthings" where operators and engineers may experiment and secure accurate data upon which to base designs of new mills, or changes in existing installations. An engineer or operator who undertook to interfere with his production while he "tried out" many of his ideas would soon be given a

"short shift" when his production records were examined by his superior.

If the American steel industry is to maintain its present position among the industries of the world a great deal of work of the character proposed by the Bureau of Rolling Mill Research will have to be done, and it should be done by a body of men specially trained and having access to proper equipment designed for this purpose.

A rolling mill to be used for experimental purposes should be equipped with recording instruments which will enable the observers at all times to determine accurately just what is taking place in all parts of the mill during an experimental run.

The requirements for such a mill might be classed under the following heads:

1. Plenty of power.
2. Ability to reverse the direction of rotation at will.
3. A wide range of speeds.
4. A wide range of types of mills.
5. Ability to roll a wide range of product.
6. Ability to assemble a wide range in sizes of rolls.
7. A set of measuring instruments which will enable the accurate determination of what is going on during the experiment.
8. The equipment must be so designed that alterations to suit special experiments may be easily made at a comparatively small cost.

This article is the first of a series which will describe in detail the design of the experimental rolling mill of the Bureau of Rolling Mill Research, at Pittsburgh, Pa. This series of articles, while chiefly intended to describe the details of design, will in so doing give emphasis to the great possibilities for research, which such a bureau will make available to the American steel industry. The success of this project, which is of tremendous import to the steel industry of this country, will be directly proportional to the cooperation given it by the industry.

In general this might be summed up in the single word, "flexibility."

The Carnegie Institute of Technology will set aside building space approximately 30x135 ft. to house the mill and its auxiliary equipment.

The mill and drive will consist of a motor, suitable gear reduction, three stands of pinion housings, three stands of mill and three lines of shoe plate.

The auxiliary equipment will consist of two stationary heating furnaces, one movable electric furnace, two hot saws and a roll lathe, with roll racks, steel racks, etc.

The source of power supply for driving the mill motor will be obtained from a 500 kw 230 volt dc Westinghouse generator direct connected to a 30x42-in. Mesta uniflow steam engine.

This generator will be withdrawn from the general power circuit at the Institute during the operation of the experimental mill and will be placed in the main mill motor circuit during that period.

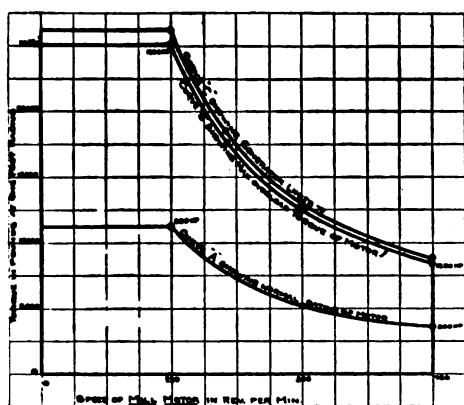


Fig. 1.

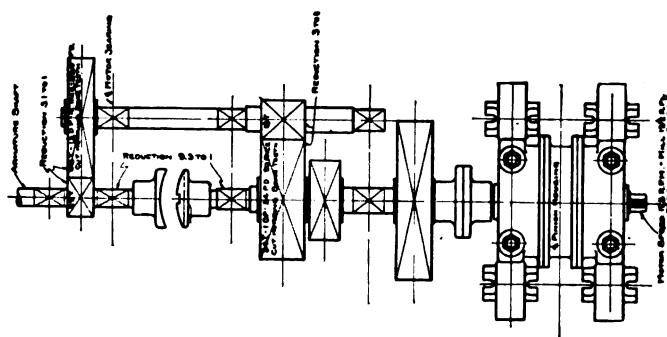
The fields of both mill motor and the generator will be excited from the regular 230 volt supply. The generator is to be operated at all times as a shunt type machine.

The motor will have both series and shunt field windings. The series will be controlled by a double throw knife switch located on the frame of the motor. When operating as a reversing motor, the series field will be cut out of the motor circuit, and when operating as a uni-directional drive the series fields are to be left in the motor circuit, the motor then operating compound wound. When ready for operation, the engine driven generator will be running at full speed, the controller rheostat handle being in the "off" position. The generator will have no current circulating through its fields and consequently will not generate either voltage or power. The mill motor will be stationary, having maximum current circulating through its shunt field, but having no voltage impressed across its armature terminals, will not revolve. On moving the rheostat handle to the first operating point, the generator field will then receive the minimum current, as there will be a maximum amount of

resistance in the shunt field circuit. This field current will cause the generation of a very low voltage, and a current at this low voltage will be sent to the mill motor armature, causing it to start revolving at a very low rate of speed. The direction of revolution of the motor armature will be regulated by the direction in which the rheostat handle is moved, i. e.: to the right or to the left.

The speed at which the mill motor runs is practically proportional to the impressed voltage and is independent of the load, up to full field on both motor and generator.

The controlling rheostat will have 50 contact points for rotation of the motor in either direction. The motor and generator rheostats are operated from the same handle, and are so arranged that the motor field cannot be weakened until the generator field has reached its full length. The first 20 of these points will gradually cut out the resistance in series with the generator field, thereby increasing the voltage of the current generated, with a resulting increase in the speed of the mill motor. At the twentieth point all resistance has been cut out of the generator field and full voltage is applied to the mill motor, which is now



GEAR DIAGRAM NO. 1

Fig. 2.

up to its speed of 250 rpm, and has its maximum field density. At the twenty-first contact point slight resistance is cut into the field current of the motor, weakening its field and increasing its speed. This is continued for the remaining 29 steps when the speed of the motor has reached the maximum of 750 rpm. When operating as a reversing mill, the motor is rapidly brought to rest by regenerative braking. This is accomplished by lowering the voltage of the generator below that corresponding to the speed of the motor and pumping power back into the generator. A large proportion of the decelerating energy is reclaimed by the resulting increase in speed of the generator flywheel. Reversing the mill motor will be accomplished by reversing the direction of the current in the generator field. This avoids the difficulty of handling and reversing the heavy currents in the armature circuit.

Fig. 1 shows the torque speed curves of both motor and generator. Curve A is the normal continuous duty curve of the motor. Curve B is the maximum torque curve of the motor, and curve C is the maximum torque curve of the generator.

Special attention will be given the design of the motor armature, since considerable energy is required to overcome the flywheel effect of the armature when reversing.

The control will be accomplished by means of a hand-operated rheostat and will be so interlocked that the motor will always have a full field when starting. Between the generator and the motor a manually operated high capacity circuit breaker will protect the generator from excessive overload. Several sets of push buttons will be located at various points about the mill and pulpit, to trip this circuit breaker in case of emergency.

In addition to the hand-operated rheostat for controlling the motor the pulpit will contain a switchboard on which will be mounted an indicating ammeter and volt meter as well as the necessary signal lights to indicate the position of the main circuit breaker.

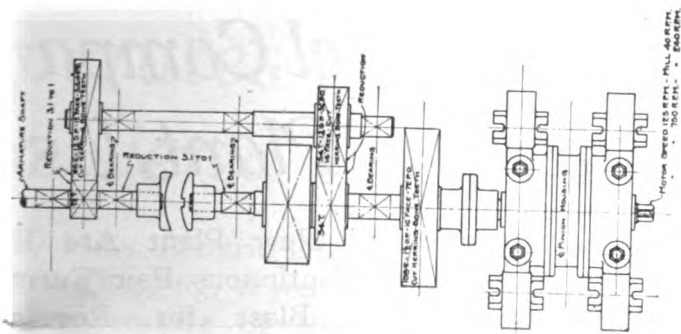
For observing the power conditions when the mill is operating, the following instruments will be used:

One indicating dc volt meter—zero center.

One indicating dc ammeter—zero center.

One indicating speed meter for mill motor—zero center.

One indicating speed meter for generator—single deflection.



GEAR DIAGRAM NO. 2
Fig. 3.

One graphic dc volt meter—zero center.

One graphic dc ammeter—zero center.

One graphic speed meter for motor—zero center.

One graphic speed meter for generator—single deflection.

One magneto connected to motor shaft.

One magneto connected to generator shaft.

The graphic instruments will have one chronographic pen on each margin, one to be connected to a seconds pendulum, and the other for recording the exact revolutions of the mill. This set of pens will enable all recording diagrams to be connected together when they are plotted on the final report charts.

The recording instruments will all be of the switchboard type. As it is the intention of the Bureau to run repeated tests it would be neither convenient nor good engineering to use portable test instruments for this work.

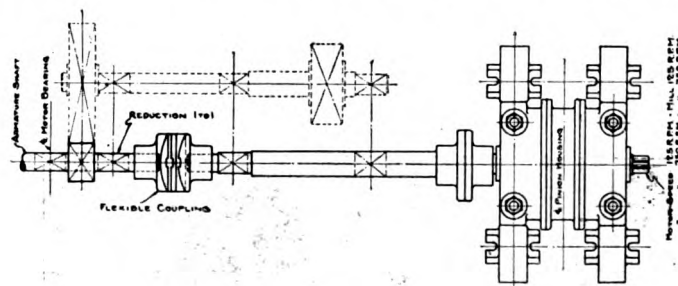
Figs. 2, 3 and 4 show three possible assemblies of the gear reductions between motor and mill. In Fig. 2 the power is transmitted from the armature shaft through the motor pinion and gear to the jack shaft with a reduction of 3.1 to 1. From the jack

shaft through its pinion and the main driving gear to the main shaft a second reduction of 3 to 1 is secured, making a total reduction of 9.3 to 1 between motor and mill.

It will be noted that there is a second gear on the main driving shaft which is entirely idle. This is used in other combinations.

With the arrangement just described it will be possible to deliver a maximum overload torque of 230,000 pounds ft. to the mill from 0 to 27 rpm in either direction. From 27 rpm to 81 rpm at the mill, the torque is gradually decreasing until at full motor speed of 750 rpm, corresponding to 81 rpm at the mill, there will be delivered a mill torque of 78,000 pounds ft. The speed range of the mill shaft will vary from 81 rpm in one direction to 0 and up to 81 rpm in the opposition direction. This variation in speed will be in addition to any variation that can be obtained at the extension of the different pinion housings.

Fig. 3 shows a second combination of gearing. In this arrangement the main driving pinion has been changed, and the second set of gears is now a 1 to 1 ratio, giving a total reduction between motor and mill of 3.1 to 1. This will give a maximum overload torque of 78,000 pounds ft. at mill speeds between 0 and 81 rpm in either direction, with a gradually decreasing torque, which at full motor speed gives 26,000 pounds



GEAR DIAGRAM NO. 3
Fig. 4.

ft. at 240 rpm at the mill. The speed range with this combination of gears is therefore from 240 rpm in one direction to zero to 240 rpm in the opposite direction.

It is expected that about 90 per cent of the work will be done with this combination of gears as the 40 rpm is close to the sheet mill speed, and 240 rpm is a good bar mill speed.

When a mill speed greater than 240 rpm is desired the jack shaft will be lifted out of its bearings and the missing parts of the flexible coupling slipped into place. The mill will then be direct connected as shown in Fig. 4. In this drawing the jack shaft is indicated in dotted lines and the gears have been stripped from the main shaft. At 240 rpm the largest gear will have a rim speed of nearly 5,000 ft. per minute. This rim speed would rise to nearly 15,000 ft. per minute at 750 rpm. It was therefore thought advisable to replace this main shaft with a second shaft or at least to strip the gears from the main shaft before attempting to run at the high speed. With this arrangement the motor will deliver a maximum torque of 25,000 pounds ft. to the mill.

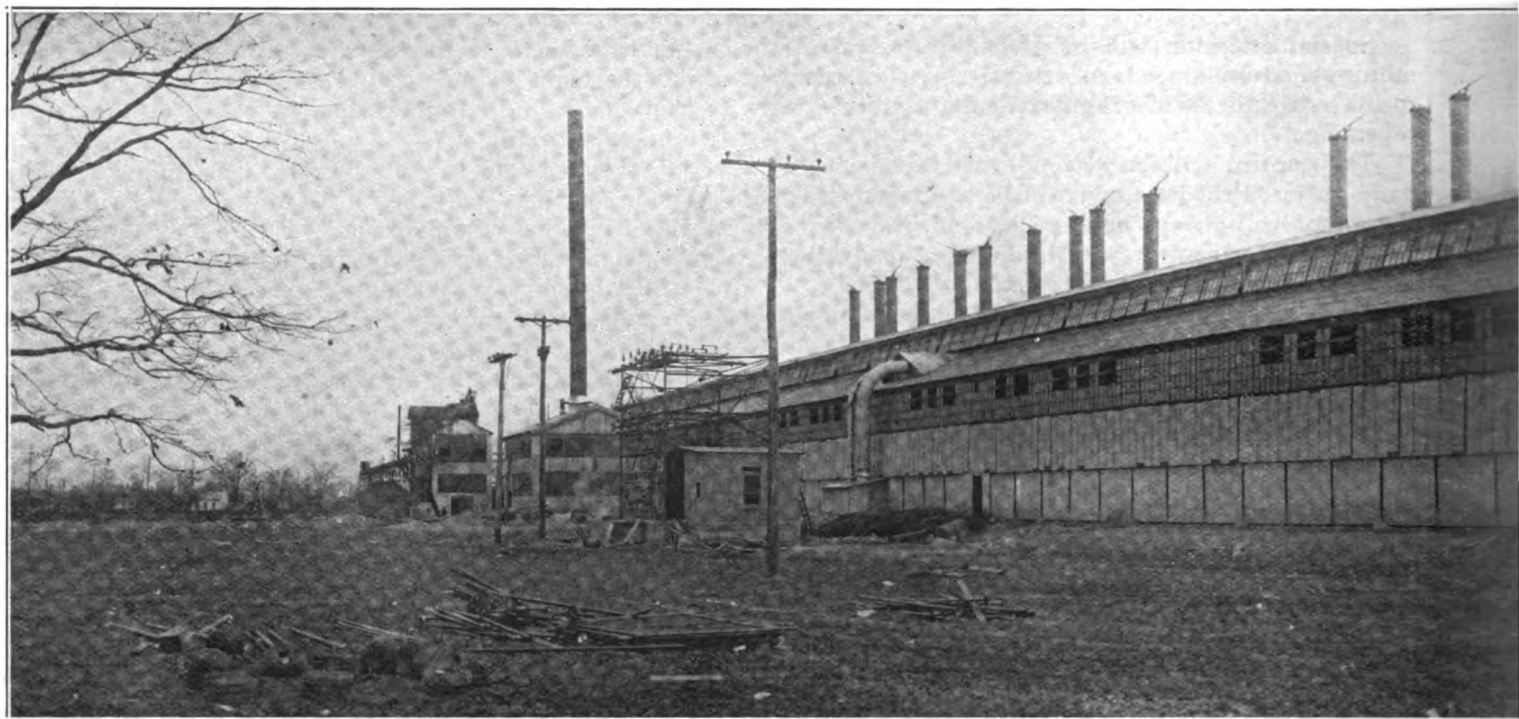


Fig. 1—General view of the Falcon Steel Company's new sheet mill. The coal milling plant and coal storage can be seen at interest to note that no smoke is coming from the stacks.

THE Falcon Steel Company, of Niles, O., one of the most modern and up-to-date sheet mills in the Mahoning Valley, recently started operation, producing every variety of sheet from common galvanizing to high-grade automobile sheets. The

Falcon Steel Company Modern Plant Uses

Features of New Plant Are Extra Coal Fuel, Continuous Pair Furnaces, and Steam Blast for Regulating

new mill is equipped with all the modern appliances that recent practice has proven to be helpful in the production of high-grade work, both as regards quality and quantity of product. The more important installations in the new plant include extra heavy mills, electric drive, powdered coal fuel, continuous pair furnaces, electric furnace chargers, Baird water cooled floors, and steam blast for regulating the temperature of the hot rolls.

Buildings.

The hot mills are housed in a steel building 702 ft. long and 70 ft. wide, the furnace building being 598 ft. long and 50 ft. wide. The cold roll and annealing building is 650x80 ft. and the galvanizing building 234x70 ft. The buildings were furnished by the McClintic-Marshall Company, and are of steel construction throughout, fitted with Lupton steel sash. Wood block floor is installed in the warehouse.

Special attention has been given to ventilation and natural lighting. The artificial lighting is so arranged as to give 5 to 7-foot candles of light at all parts of the plant, giving ideal working conditions either day or night.

Hot Mills.

The present equipment, which is to be added to

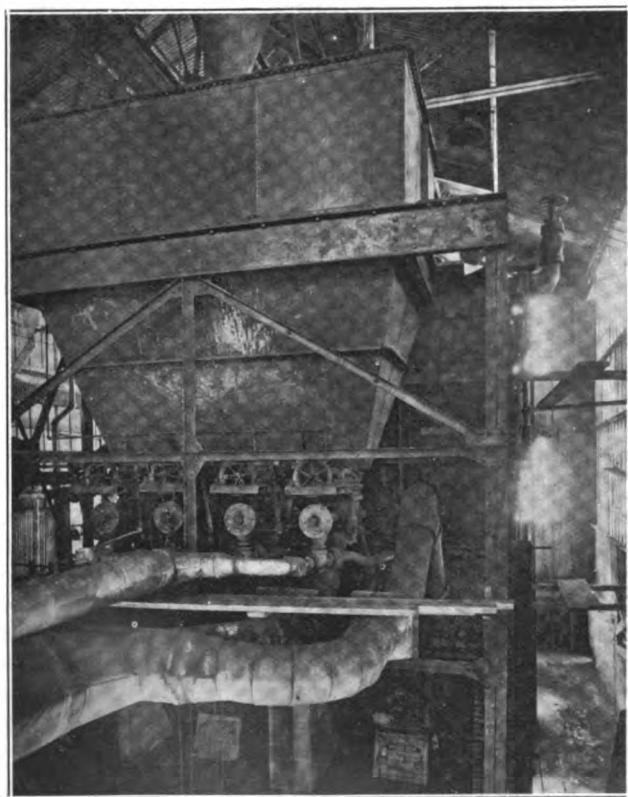
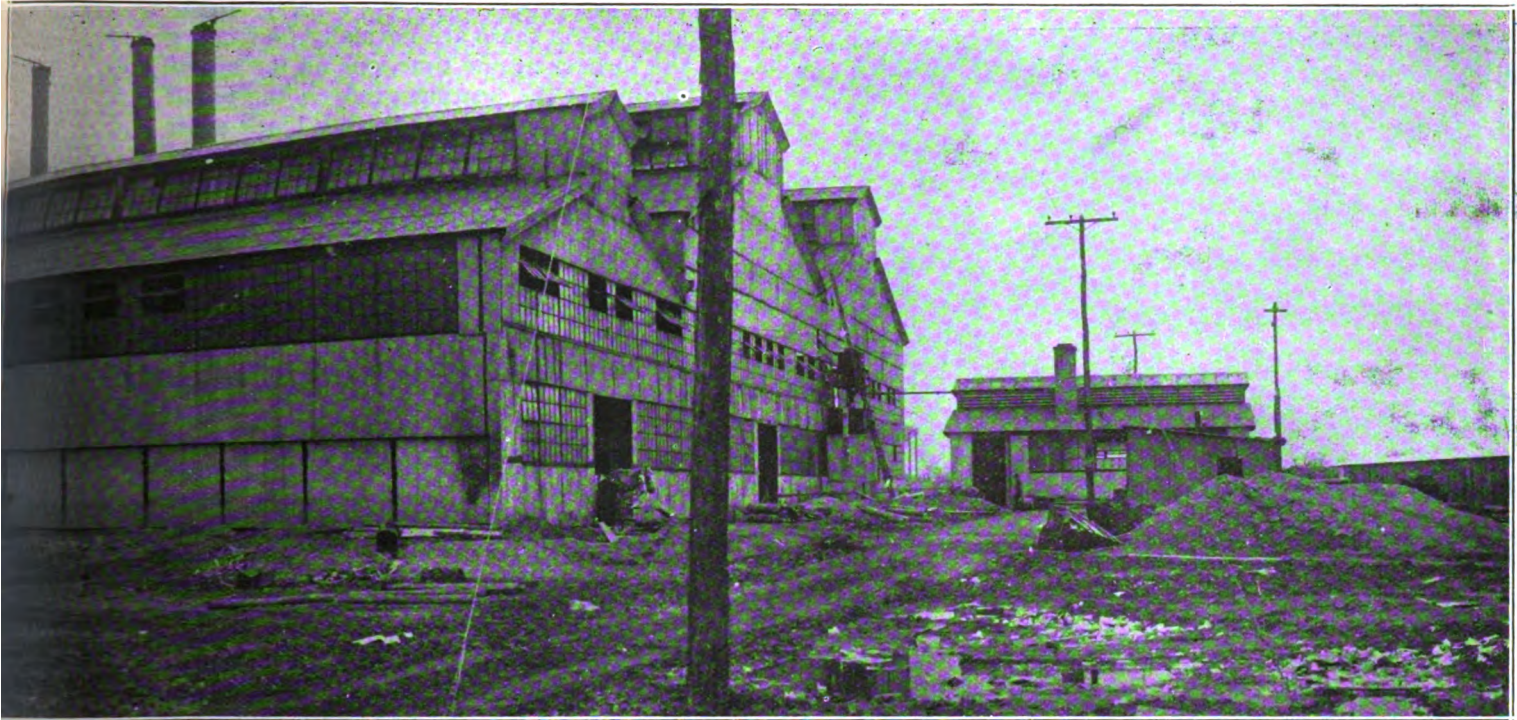


Fig. 2—The front of the boilers in the power plant. Illustration shows four controllers and dust-tight gates attached to fuel bin. Hand chains operate gates and control fuel feed to burner.



the left beyond the power plant stack. At the time when this photograph was taken the mill was in operation and it is of Powdered coal is used throughout the entire plant.

Operates Sheet Mill Powdered Coal Fuel

**Heavy Mills, Electric Drive, Powdered
Electric Charging, Water Cooled Floors
the Temperature of the Hot Rolls**

later, consists of one pinion-driven jobbing mill 29" diameter with balanced roughing and jump finishing stands with 22" necks. There is one jump roughing mill and seven stands of 29" finishing rolls; these mills were built by the United Engineering & Foundry Co., the housings weighing 34,000 pounds each. Another jobbing mill will be added shortly.

Drive.

The hot mills are driven through a Falk gear drive with about 8 to 1 reduction and the mills arranged half on each side of the drive which consists of a 1,600 hp General Electric motor of 2,200 volts, three phase, 60 cycle, 240 rpm. The electric power is furnished by the Mahoning and Shenango Electric Power Company at a tension of 22,000 volts which is stepped down at the transformers to 2,200 volts for the mill motors. A motor-generator set converts sufficient power into direct current of 240 volts for the cranes and floor motors.

The drive is of the usual Falk construction consisting of single reduction gears of the cut herring bone type, as shown in Fig. 10, and revolves the rolls at a uniform speed of 28 rpm.

Furnaces.

The continuous pair of bar heating furnaces are

of the Hagan-Allis type, fitted with electric charging device shown in Fig. 7). Powdered coal is used for fuel as shown in the illustrations.

The sheet bars are placed in a charging rack at the rear of the furnaces. When a heat is charged it ad-

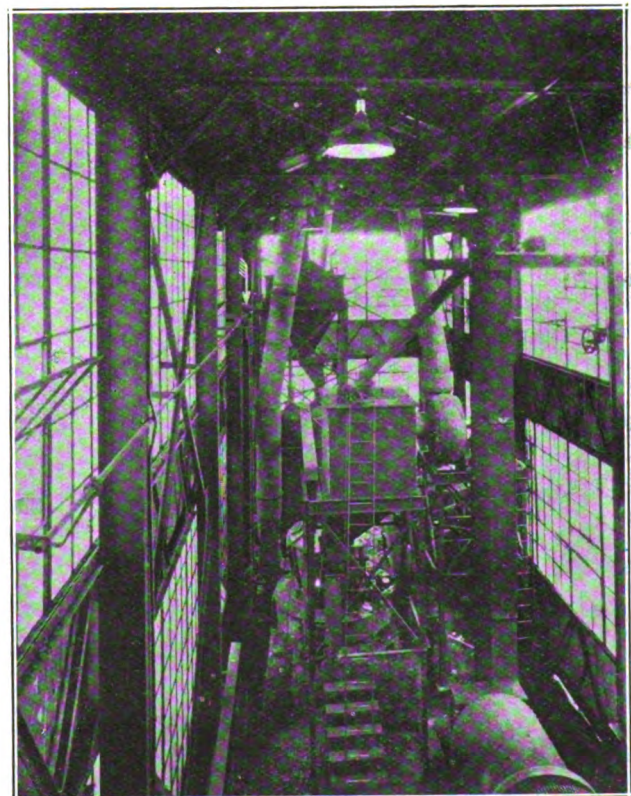


Fig. 3—View of milling plant from the top of crushed coal bin. The pulverized dried fuel bin is shown above the blowing tank in extreme background. Arrow points to the four-inch fuel transport line.

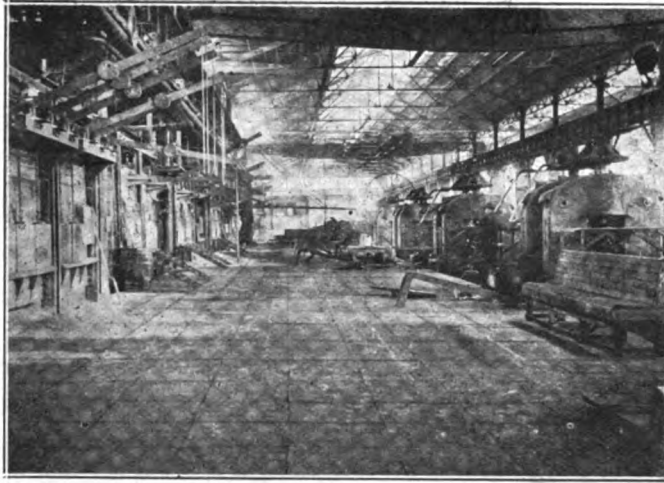


Fig. 4—View of furnaces and hot mills, showing particularly the Baird water-cooled floor.

vances the bars already in the furnace and the front bars drop from the heating grooves onto the hearth of the furnace, where they remain without further piling, until they are drawn from the furnace for rolling. The charging head then returns to its original position, thus permitting another charge of bars to be placed in the charging rack outside the rear end

of the furnace. As there are normally four charges of bars in the furnace at one time, one on the hearth and three standing in the heating grooves, the result is a soft mellow heat entirely eliminating black spots and cold ends.

The sheet furnaces are of the usual two-door type used on this work and fired with powdered coal. The pair and heating furnaces were furnished by the George J. Hagan Company, of Pittsburgh, Pa.

Annealing and Bluing Furnace.

The jobbing mill is also supplied with a Tate-Jones continuous open annealing and bluing furnace which receives the sheet as it comes from the mill and carries it on rollers, along a horizontal plane through the furnace, at the proper speed to thoroughly anneal and blue the sheet. No further attention is required after it has been entered inasmuch as a set of pinch rolls are provided at the exit end to properly discharge the sheet onto the cooling table. There are three 4-box annealing furnaces.

Water Cooled Floors.

The hot mill standings on the furnace side of the mill are of the Baird water cooled type, consisting of cast iron hollow plates, cast in one piece 2 ft. square. The plates are arranged in tiers the width of the standing, and connected together for continuous

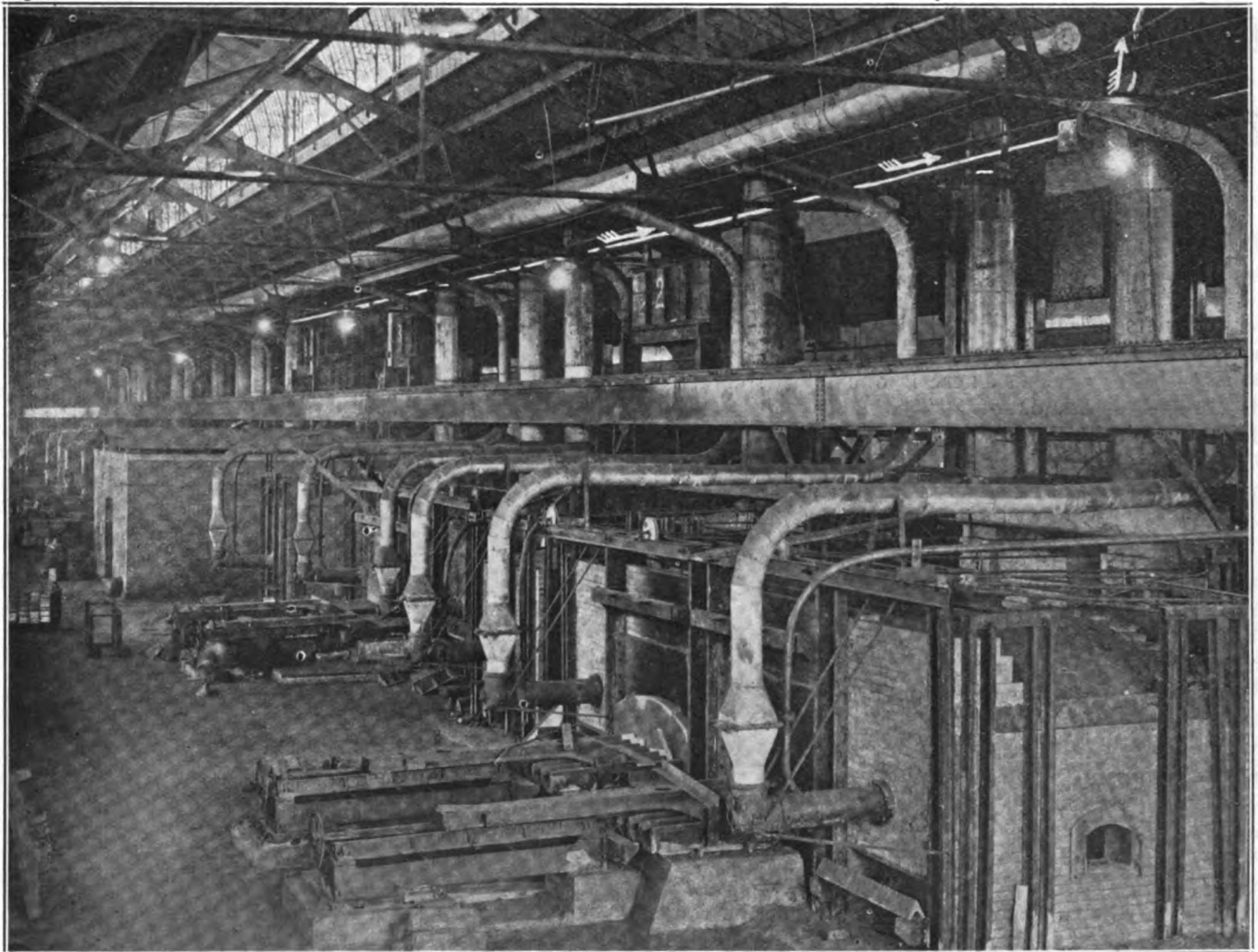


Fig. 5—General view of the back of the sheet and pair furnaces. Arrows indicate the flow of the fuel in the transport line. The Quigley air transport powdered coal system is used throughout the entire plant.

water circulation with 2-in. taper push nipples. The tiers are cross connected with each other at the ends of the standing with $\frac{3}{4}$ -in. pipe fittings, permitting the water to enter at one end of the standing and going through one tier of plates and back through the next tier until the water has traversed the entire standing and is discharged into the bosh at the opposite end. As the pressure of the main is kept in these plates at all times no hot spots can develop and the temperature of the standing is the same throughout and can be regulated by the amount of water permitted to flow through even at the end of the week. The bare hand can be held in contact with the standing at any point. The plates are of cast iron of a hollow box section, four inches deep, and can neither rust out nor warp. The standings, as illustrated in Fig. 4, were furnished by the National Roll & Foundry Co., of Avonmore, Pa.

Cold Rolls.

There are four stands of 26-in. diameter cold rolls, 38, 42, 48 and 60 inches long. These rolls are driven through a Falk drive by a 350 hp General Electric motor. The motor speed is 360 rpm. reduced to 35 rpm. on the cold rolls. These mills are in the annealing department and have housings weighing 22,000 pounds each.

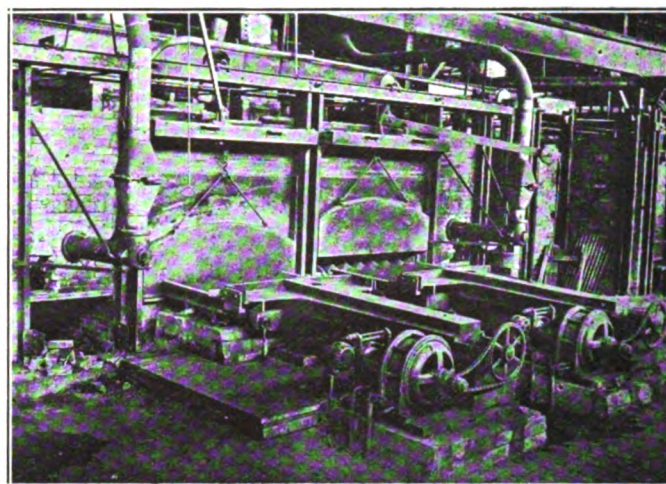


Fig. 7—Rear view of the Hagan-Allis pair furnaces showing electric charging apparatus.

The hot mills are served by one 30-ton and one 10-ton crane, these with the other cranes used in the buildings were furnished by the Morgan Engineering Company, of Alliance, O.

There is also an enclosed head motor-driven roll lathe with the gears running in oil, four steam doublers, and five 168-in. squaring shears furnished



Fig. 6—General view of entire mill showing particularly the jobbing and finishing mills. The motor and gear drive may be seen slightly toward the right of the illustration.

by the United Engineering and Foundry Company, of Pittsburgh, Pa.

Roller Levelers.

The leveling of sheets at present is taken care of

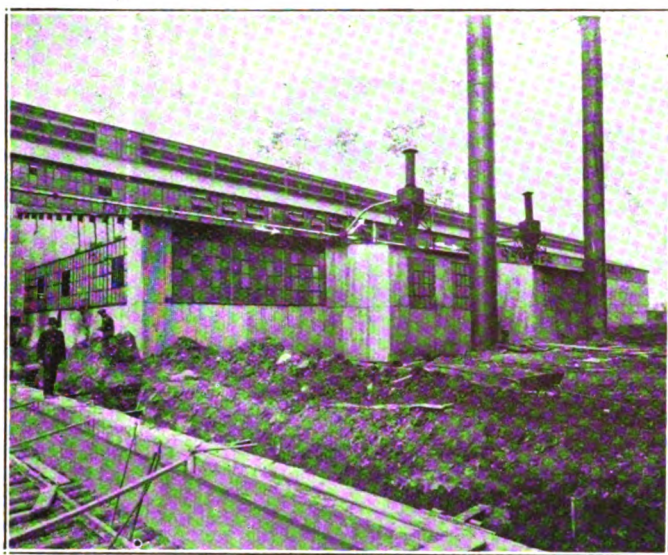


Fig. 8—Fuel transport line and collectors for annealing furnace bins. The arrows indicate flow of fuel in four-inch transport line.

by three roller leveling machines, one 72-in., one 60-in., and one 54-in. wide. These were built by McKay Machine Company, Youngstown, O. Later on a stretcher leveler will also be installed to take care of high-grade sheets.

Sheet Bar Shears.

There are two sheet bar shears on which all the sheet bars for the hot mills are sheared. One is of the upright Guillotine type, manufactured by the United Engineering and Foundry Company, and the other is an alligator shear made by Doelger & Kirsten, of Milwaukee, Wis.

Pickling Machines.

There are two double plunger picklers in the pickling department built by the Erie Foundry Company, of Erie, Pa. The railroad tracks in the cold rolling, annealing and warehouse buildings are depressed, permitting the loading to be done at floor level of cars, and all cars are loaded inside the buildings.

Steam Boilers.

The 200 hp Badenhausen steam boilers have been installed to furnish steam for the picklers and also furnish the steam necessary to control the temperature of the hot mill rolls which are fitted with a steam spreading device which projects the steam evenly in a flat fan-like layer between the two rolls from a spreader located directly beneath the fore plate.

Galvanizing Department.

The galvanizing department is supplied with three galvanizing pots and will take care of sheets 10 gauge thick and up to 48 inches wide.

The sheets are transferred from the annealing

building to the warehouse by means of electric flat cars and the warehouse floor is paved with wood block which will stand the trucking without undue deterioration.

The dial scales used in this department were furnished by Fairbanks Morse & Co. Sanitary plumbing is used throughout the plant and the drinking water is supplied from wells and piped to different parts of the plant. All the electrical equipment about the plant was furnished by the General Electric Co.

Powdered Coal.

The writer is indebted to the Quigley Furnace Specialties Company, New York City, N. Y., who furnished all the powdered coal equipment, for the comprehensive description and the accompanying illustrations of their system.

The powdered coal equipment includes a complete coal milling plant with crusher, magnetic separator for tramp iron, rotary dryer, pulverizer, and the necessary elevators, conveying apparatus and hoppers to handle the fuel during the stages of preparation. The capacity of the milling plant is 5 tons per hour. A blowing unit, having a capacity of 3 tons per charge, transports the pulverized fuel to the several departments in the mill through standard 4-in. wrought pipe. A single transport line of this size is provided with several branch lines of the same diameter leading to the different departments. One branch line leads to the sheet and pair furnaces listed below and this line also supplies, by means of an additional switching valve, the fuel for the two boilers in the power house. An extension from the same line leads to the fuel bins for the Costello continuous annealing furnace and to a bin for supplying the grease kettle, which is housed in a small out-building.

Another branch from the main transport line leads

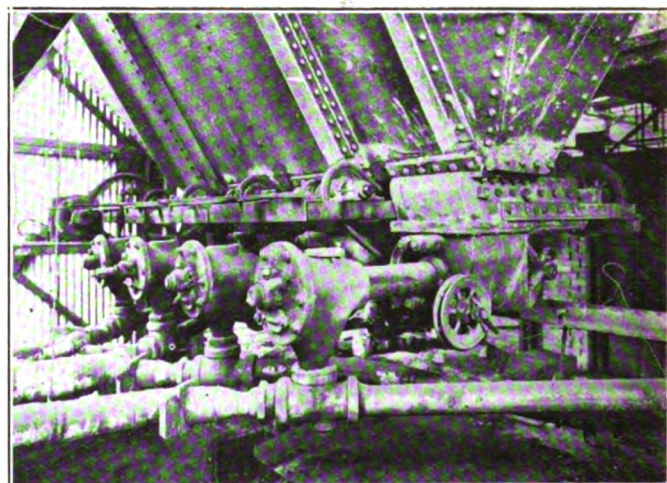


Fig. 9—Annealing furnace bin, for powdered coal, showing discharge heads of four controllers motor geared to one shaft for all four controllers. The photograph was taken during operation.

to the two annealing furnaces, provision being made for an extension of this department. The extreme end of the main transport line reaches the furnace bin for supplying the three galvanizing pots now in-

stalled. The aggregate length of the fuel transport lines is approximately 1,700 feet. A branch line leading to a blue annealing furnace is supplied by a switch valve on the line which leads to the furnace bins of the sheet and pair furnaces.

Fig. 12 gives a complete layout of the transport lines and shows location of furnaces, etc.

Boilers.

There are two boilers fired with powdered coal. These are each 200 hp Badenhausen. Fuel is supplied to these from a 10-ton pulverized coal bin. Four powdered coal feed regulators surmounted by dust-tight gates are attached to the bottom of this bin. These fuel regulators are all driven at constant speed by one 5 hp General Electric motor, 1200 rpm., which is geared to a line shaft with separate clutch for each regulator. The fuel feed to each of the four burners is controlled by means of a hand chain wheel described below. There are two pulverized coal burners for each boiler.

The primary air circuit is supplied by a No. 40 Clarage SP blower 1,000 cfm at $6\frac{1}{2}$ oz. pressure. This fan is driven by a $7\frac{1}{2}$ hp General Electric motor 1,800 rpm. The secondary air is furnished by a No. 2 Clarage multiblade fan 6,000 cfm at 4 oz. pressure driven by a 5 hp General Electric motor at 720 rpm.

Furnaces.

There are altogether seven Hagan-Allis patented double chamber sheet furnaces, one 54-in., two 42-in., four 40-in. and one single furnace 32 in. There are four double chamber pair furnaces, one 56-in., one 44-in., two 40-in., and one single chamber pair furnace 33 inch. The furnace equipment includes one Costello continuous annealing furnace, two double box double chamber annealing furnaces, one blue annealing furnace, three galvanizing posts and one grease kettle.

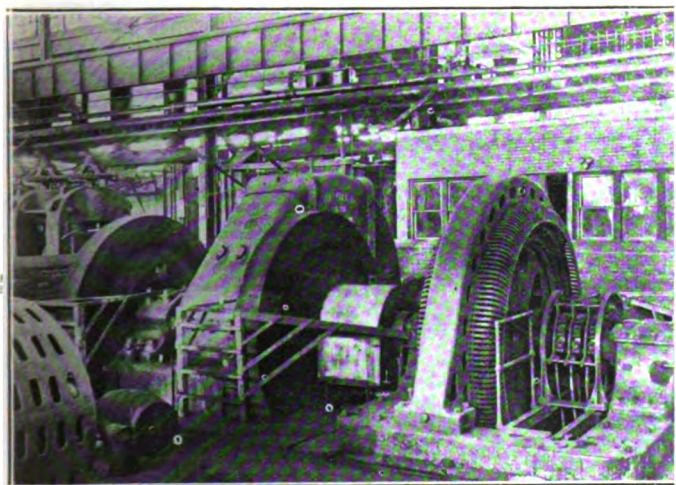


Fig. 10—Motor drive and reduction gear. The drive consists of a 1600 hp General Electric motor and a Falk gear drive with 8 to 1 reduction.

The sheet and pair furnaces are furnished with fuel from seven furnace bins. The equipment of blowing station for primary and secondary air being as follows:

Primary—One No. 40 Clarage SP blower 1,500 cfm at 6.4 oz., driven by $7\frac{1}{2}$ hp General Electric motor at 1,800 rpm.

Secondary—One No. $2\frac{1}{4}$ Clarage multiblade fan

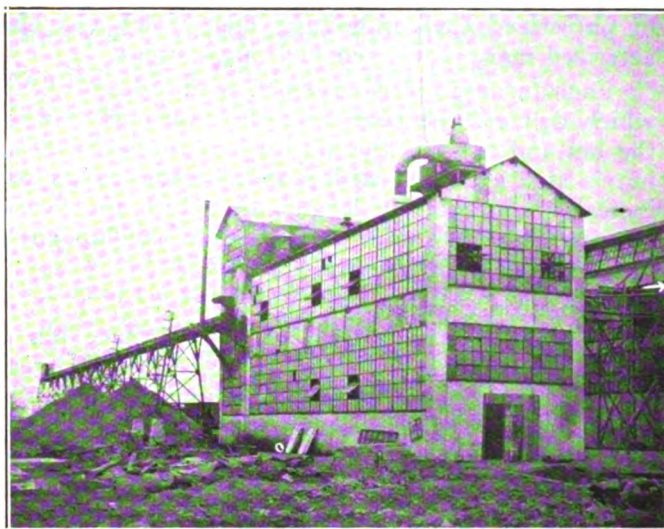


Fig. 11—Milling plant and coal trestle. The four-inch transport line passes through staging in the right, indicated by the arrow.

7,000 cfm at 1.3 oz., driven by a 5 hp General Electric motor 600 rpm.

Costello Furnace.

The primary air for the Costello furnace is supplied by one No. 40 Clarage SP blower 1,000 cfm at $6\frac{1}{2}$ oz., driven by a $7\frac{1}{2}$ hp General Electric motor 1,800 rpm, and the secondary air is supplied by a No. $1\frac{1}{2}$ Clarage multiblade fan 4,000 cfm at 1.3 oz., driven by a 5 hp General Electric motor at 900 rpm.

Distribution of Fuel.

The system of distribution from milling plant to furnaces and boilers differs from screw conveyor or a high pressure blast system in that the fuel is transported in bulk from the pulverizing plant through the 4-in. mains to bins located at the furnaces as listed above. By this method the fuel can be handled rapidly. The single 3-ton blowing tank now installed is amply adequate for the fuel needs of all furnaces and boilers.

The pulverized fuel is admitted into the blowing tank from the pulverized fuel bin by opening a dust-tight gate. The blowing tank rests on a scale equipped with an easy reading dial which indicates at all times the amount of fuel in the tank. When sufficient amount of fuel has been admitted the dust-tight gate is closed and the requisite amount of compressed air admitted.

A shut-off valve leading to the fuel distribution line is then opened and the compressed air starts the fuel along the line. From the main transport line the fuel is diverted to any of the branch lines and thence to the furnace bins by means of switching valves appropriately placed along the line and operated from the floor by hand chains.

The scale dial at the blowing tank will therefore

indicate the amount of fuel transported to any individual bin and thus enable an accurate record being made of fuel consumption for each furnace or boiler supplied by that bin.

As the equipment throughout is dust-tight and the furnace bins entirely enclosed, there is no leakage of pulverized coal or floating dust which has characterized many powdered fuel installations.

Each furnace bin is equipped with a dust collector which delivers the coal from the transport line into the bin and releases the air used in transport. Each bin is also equipped with a stock tester gauge with indicator conveniently located by which the furnace operator can determine at any time the amount of fuel required to fill the bin.

Fuel and Air Control.

Attached to the bottom of each furnace bin directly beneath dust-tight gates are the fuel feed regulators which are one or more in number, depending on the number of furnaces served by the bin. These regulate the amount of fuel fed to the burner. This regulation is accomplished by turning a hand wheel and permits of very fine adjustment though the operation is extremely simple, being similar to that of opening or closing an oil valve.

These regulators are driven by a constant speed motor, in some cases in multiple by means of line or

connecting shafts. The feed screw in the regulator is driven at constant speed and the adjustment of fuel fed to the burner is accomplished by means of a diaphragm or a pair of shutters operated by the hand wheel above referred to, which closes around the screw to give an adjustable opening to the discharge head.

The low pressure primary air system carries the fuel from the ejector to the nozzle of the burner. Much of the air pressure is dissipated in the passage of the fuel from regulator to burner so that the fuel really enters the furnace at extremely low pressure.

The secondary air or combustion air (large volume) mingles at very low pressure with the coal particles at the nozzle of the burner. Both primary and secondary air as well as fuel supply are under close control so that any condition of flame desired may be obtained.

The primary air is in volume about 1/7 of the amount necessary for combustion, so that no combustible mixture exists until the fuel reaches the nozzle of the burner.

Among the important features of this system is its cleanliness. As the fuel is carried in dust-tight equipment from blowing tank to burner there is entire freedom from floating dust.

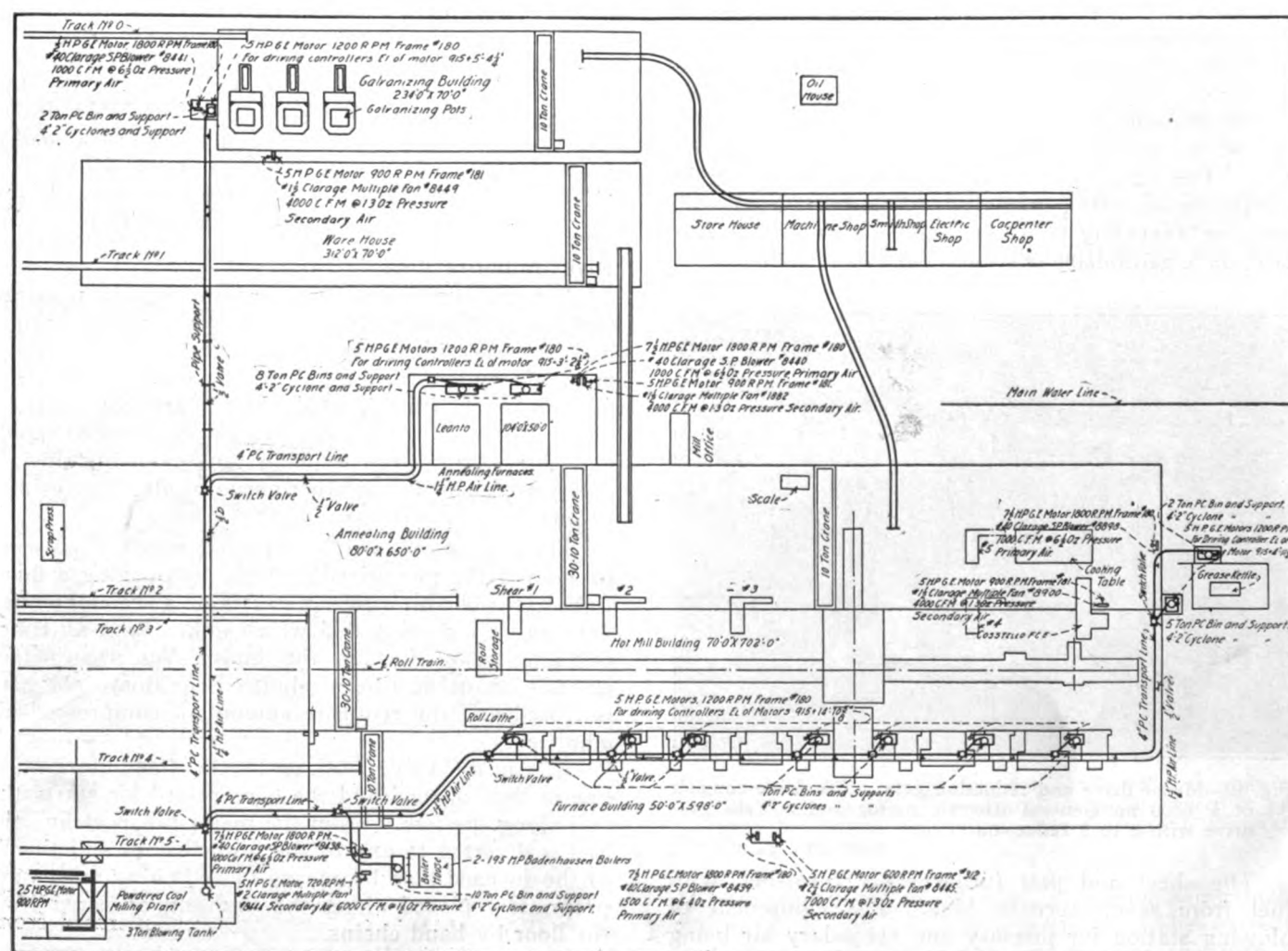


Fig. 12—General layout of Falcon Steel Company. The illustration shows chiefly the powdered fuel installations.

Using the Microscope to Detect Causes of Failure of Steel Castings

How the Microscope Can Determine the Correct Heat Treatment to Give to a Steel Casting—Proper Annealing Temperatures Indicated—Incorrect Treatment Corrected by Photomicrographs.

By O. A. KNIGHT,

Assistant Professor of Metallurgy, Pennsylvania State College.

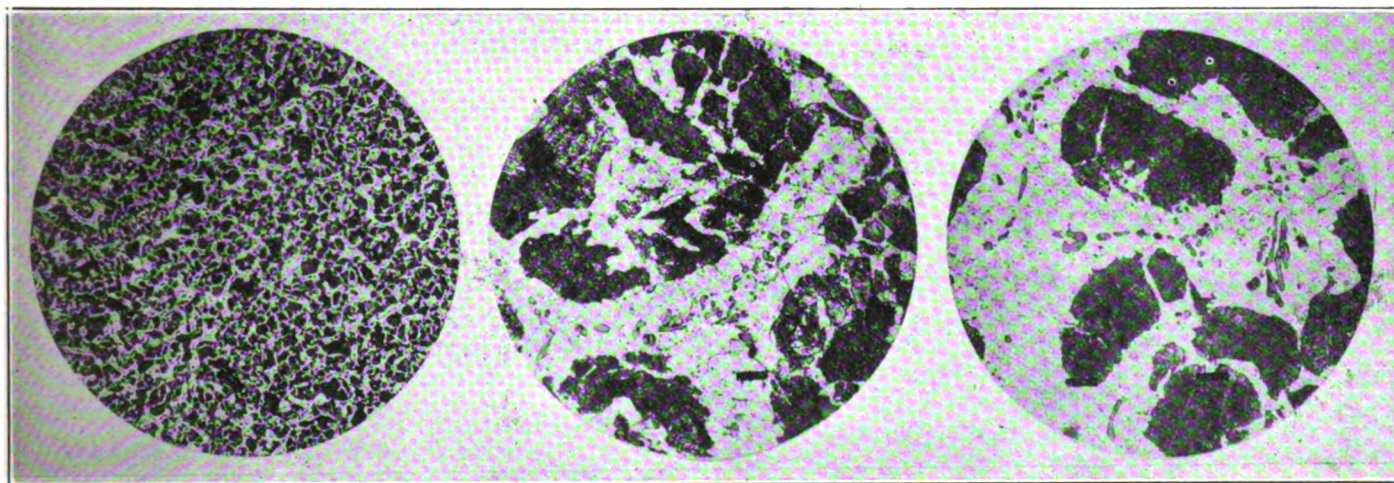
THE microscope is widely recognized as a very valuable piece of apparatus in modern iron and steel works laboratories and its uses have been discussed from time to time in many of our well known texts and technical journals. The author therefore does not in any way claim originality in advocating the use of the microscope in connection with the manufacture of steel castings, but he does wish to extend the knowledge of this method of investigation to all who are directly connected with the manufacture of steel castings. It is hoped that the information here presented will be of material assistance to many in determining the cause of failures as well as in finding a means of preventing them. Defects other than those ordinarily revealed by the microscope, such as pin holes, surface defects, etc., are also mentioned.

Failure of Cast Steel.

The failures most common to cast steel are due either to improper annealing or non-metallic inclusions, both of which generally result in low elongation and contraction of area. Microscopic examination of the specimen in the unetched condition reveals the presence of non-metallic inclusions. The most harmful arrangement of these inclusions in cast steel is around the grain boundaries and this can best be determined by examination of the polished surface after etching with nitric acid. Mi-

crograph No. 1 at 50X shows a specimen of cast steel, after etching with 4 per cent nitric acid in alcohol, which contains a number of slag inclusions. Micrograph No. 2 at 500X shows the same specimen after etching with 4 per cent nitric acid at the higher magnification. It will be seen that the slag forms a network in the ferrite areas around the grains. Such a specimen as this has practically no ductility. When the inclusions are present to a lesser extent, even though they are in this network formation the casting can generally be saved by quenching and drawing if this is permissible. By so doing the slag is scattered and distributed more or less evenly throughout the mass and in this condition is much less harmful. The quenching should generally be done from 950 degrees C. or 1,000 degrees C., followed by drawing just under the critical range, say at 675-700 degrees C. When, however, a specimen contains such a quantity of slag as shown in micrograph No. 2, the best recommendation is to have the casting scrapped as further heat-treatment will very likely be of no use. If, on the other hand, a limited amount is present, the chances of imparting to it the desired properties by quenching and drawing are such as to warrant a trial.

Improper annealing, of course, can be corrected by re-annealing, making sure the proper temperature is employed. Micrograph No. 4 at 50X shows the structure



Photomicrograph No. 1.

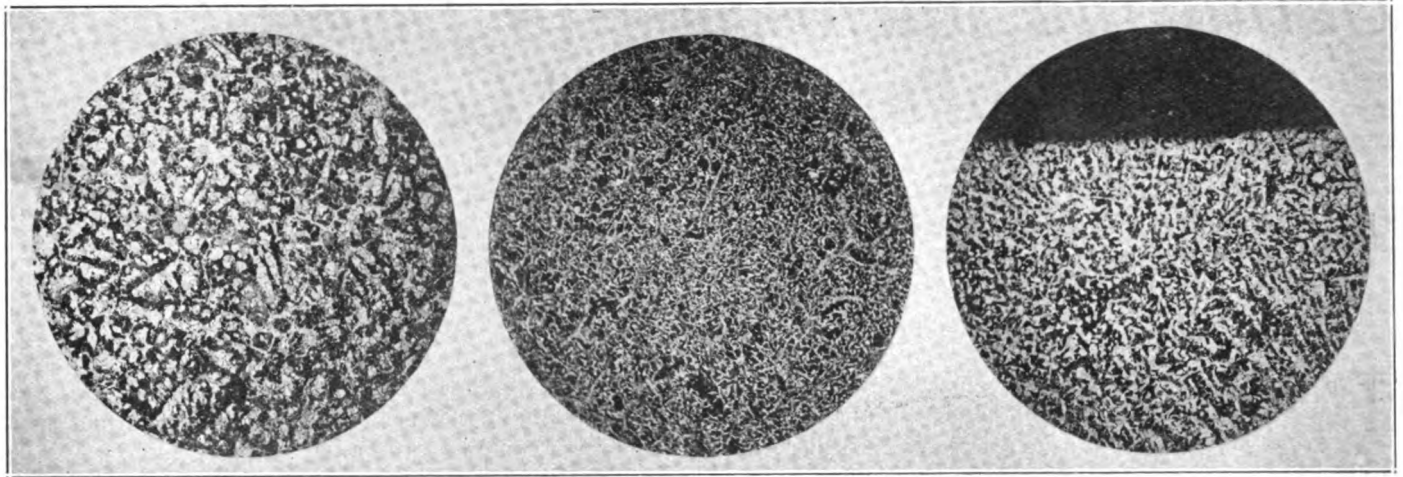
Cast steel, etched with 4 per cent HNO₃, showing slag inclusions. Magnified 50X. Half reduction.

Photomicrograph No. 2.

Same specimen as shown in photomicrograph No. 1, showing structure at higher magnification. The continuous network of slag inclusions is to be noted in the ferrite. Magnified 500X. Half reduction.

Photomicrograph No. 3.

Same specimen and same etching as shown in No. 2, only at slightly different location, also showing slag inclusions. Magnified 500X. Half reduction.

**Photomicrograph No. 4.**

Cast steel not properly annealed. Original ingotism shown. Etched 15 seconds in 4 per cent HNO_3 . Magnified 50X. Half reduction.

Photomicrograph No. 5.

Same steel as shown in photomicrograph No. 4, after having been annealed two hours at 950°C . Etched 15 seconds in 4 per cent HNO_3 . Magnified 50X. Half reduction.

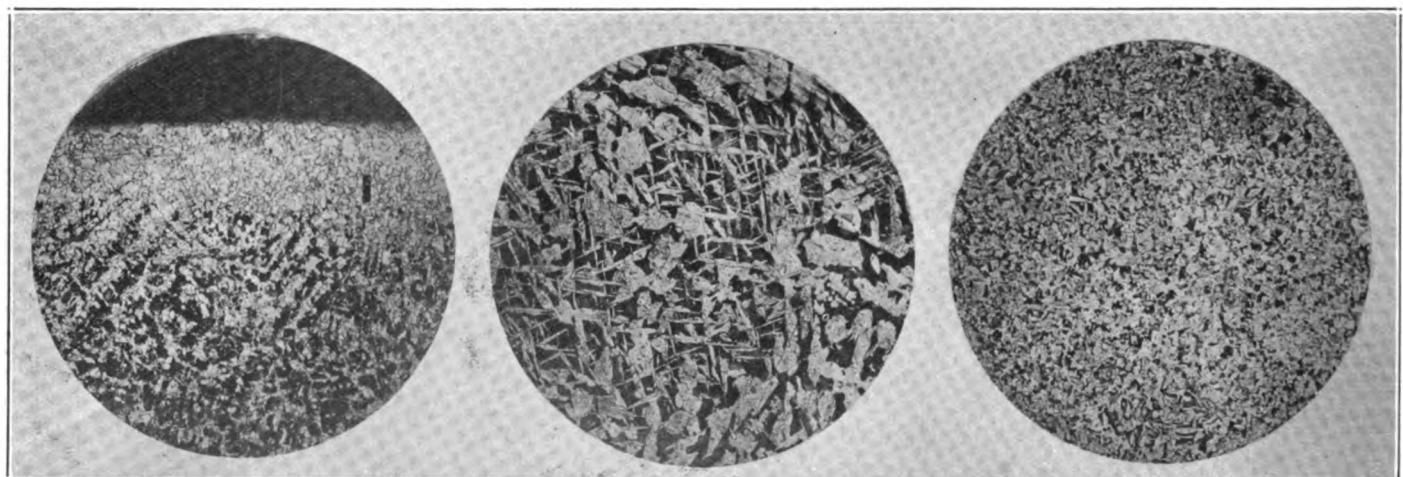
Photomicrograph No. 6.

Cast steel after annealing 2 hr. at 900°C , showing edge specimen which is not decarbonized. Etched 15 sec. in 4 per cent HNO_3 . Magnified 50X. Half reduction.

developed by nitric acid etching of a casting which was not annealed sufficiently long, nor at a high enough temperature to completely destroy the original ingotism. Such a steel will show a low value for the elongation and contraction of area. This deficiency can be overcome by a properly conducted re-anneal. Micrograph No. 5 shows the same steel as micrograph No. 4 after a proper annealing treatment.

In order to determine accurately the annealing treatment to which a casting has been subjected a portion of the casting itself should be examined before it is sand blasted and cleaned. The surface should be carefully inspected and specimens should be prepared for microscopic examination with the polished surface normal to the outside surface of the casting. Care should be ex-

ercised to avoid the removal of any scale from the surface. This examination, if properly carried out, will show whether the surface has a heavy oxide scale with little, if any, decarburized metal beneath, or whether it has very little oxide scale with a deep layer of decarburized metal. The former condition is evidence of the annealing operation having been conducted at a high temperature. The thickness of the scale enables one, after a little experience, to judge with a fair degree of accuracy the duration of the high temperature. The latter condition is assurance of a long anneal at a low temperature. Micrograph No. 6 at 50X shows the edge of a casting annealed at a comparatively high temperature, say 900°C . As will be seen there is very little decarburization and the carbon content near the edge (the oxide

**Photomicrograph No. 7.**

Cast steel annealed 10 hr. at 780°C ., showing deep decarbonization and interior metal not properly refined as to structure. Etched in 4 per cent HNO_3 . Magnified 50X. Half reduction.

Photomicrograph No. 8.

Cast steel which before microscopic examination was claimed to have been properly annealed. This shows the typical cast or Widmanstätten structure. Etched in 4 per cent HNO_3 . Magnified 50X. Half reduction.

Photomicrograph No. 9.

Same steel as shown in No. 8 after annealing two hours at 950°C . Here a well-refined grain is shown. The carbon percentage in this steel is .24 per cent. Etched 15 sec. in 4 per cent HNO_3 . Magnified 50X. Half reduction.

scale has been removed) is practically the same as farther back. Micrograph No. 7 shows a casting annealed for a long time at 780 degrees C. This shows the steel to be almost completely decarburized to a considerable depth, beyond which the original ingotism still exists. This is evidence that the annealing was conducted at too low a temperature.

Another example illustrating the effect of annealing on cast steel is shown in photomicrograph Nos. 8 and 9 at 50X. No. 8 showing the "Widmanstätten" structure, represents the structure existing after it was claimed to be properly annealed at 800 degrees C. This specimen was re-annealed two hours in a laboratory furnace at a temperature of 950 degrees C. and furnace cooled. After this treatment the structure shown in photomicrograph No. 9 at 50X was found. It will be seen by comparing the two structures that annealing at 950 degrees C. has completely destroyed the original casting structure shown in photomicrograph No. 8 and that the grain is completely refined. The carbon percentage in this steel was .24 per cent. The well-refined grain shown in photomicro-

graph No. 9 will give a much higher value for the elongation and contraction of area than is given by the type of structure shown in photomicrograph No. 8, together with equally high or higher strength.

In addition to the difficulties already mentioned it sometimes happens that a great deal of trouble arises from "pin holes" or other surface defects of steel castings. Pin holes, that is, porosity on the surface of castings is generally a result of either deficient deoxidation of the steel or of pouring in green sand molds which are not porous enough to permit the ready escape of the evolved gases. A careful study into the process by which the steel is made together with the type and condition of the molds employed should soon enable an experienced investigator to determine the cause of the difficulty. Whether or not the molds are uniformly rammed and vented is very important and many castings are of such size and shape that dry sand molds are necessary. All these details have been so ably discussed in texts devoted primarily to this phase of work that nothing more need be said here.

By-Product Coke and By-Products of Coal

Early Development of By-Product Coke Ovens—Superiority of By-Product Ovens—Domestic Coke—Recovery and Use of By-Products Such as Ammonia, Benzol, Coal Tar Products and Gas.

By T. E. PIERCE,

Semet-Solvay Company, Cleveland, Ohio.

THE development of the by-product coke oven has been due to two conditions: First, the growing scarcity of coal suitable for coke making in beehive ovens, and, second, the increasing demand for the by-products recovered from coal coked in by-product ovens.

We are told that a German chemist made the first attempt to recover ammonia and tar as by-products from a coke oven in 1771, but his work was of little or no practical value.

The limitation of the beehive oven for making coke are the results of its shape, and the inefficient manner in which heat is produced and utilized. Heat for coking the charge is received from the heat stored in the walls of the oven and from the combustion of the gases evolved from the coal in the space above the coking mass. In the latter part of the coking period it is also necessary, in the case of low volatile coals, to burn a part of the fixed carbon in the coal to secure the necessary heat, although this occurs to a lesser extent in coking any coal.

Early Development of By-Product Ovens.

To improve these conditions, European coke makers changed from the original round oven of moderate size to one of rectangular shape. In order to secure more heat for coking larger charges and to increase the yield by excluding air from the coking chamber, the gases escaping from the oven top were conducted through flues built in the oven sides, and thence to a

smoke stack. This innovation resulted in the abandonment of the old round non-by-product retort oven. This type of oven had a long narrow coking chamber, similar in form to that of the modern by-product oven. No combustion whatever took place in the oven itself, the heat being supplied entirely by gas burning in the flues surrounding the coking chamber.

This retort oven is vastly superior to the original beehive oven because it makes possible the coking of coals of lower volatile matter, by virtue of the more economical use of heat, increased the coke yield, due to the exclusion of air from contact with the charge, and produced a stronger coke on account of the greater depth and closer packing of the coal charge.

Conducting the gases coming from these retort ovens through apparatus for the recovery of by-products before passing to the oven flues was but another step forward and no change was necessary in the construction of the oven itself. Many different types of by-product or retort ovens were designed, and their early development was very slow. Time and experience eliminated the unsatisfactory designs and left a few standard types of ovens.

One of these early types that has survived the test of experience was invented by Lewis Semet, a Belgian, in the interests of Solvay & Cie, Belgian manufacturers of soda ash. Ammonia is a very important raw material in making soda ash and in order to increase the supply, Earnest Solvay secured Semet to

build a by-product coke oven plant for the firm. In 1882 Semet built a battery of 6 ovens, according to his own original design, at the Belle-Rue pit of the Quest de Mons colliery.

These, the first Semet-Solvay ovens, proved very satisfactory and others of similar type soon followed in England, as well as on the Continent. The first American Semet-Solvay ovens were constructed at Syracuse, N. Y., in 1893, for the Solvay Process Company. These were the first by-product coke ovens erected in the United States and are still in operation.

Superiority of the By-Product Oven.

As before stated, some of the fixed carbon of the coal is consumed in the manufacture of beehive coke. In the by-product oven air is excluded from the coking chamber during the entire period, thus eliminating the possibility of any loss of fixed carbon by combustion. In addition to this, some of the hydro-carbon gases passing up through the deep charge, are decomposed and carbon is deposited in the coke, increasing the residual mass.

In 1917, according to the United States Geological survey, the yield of coke in beehive ovens was 63.5 per cent, as compared with 71.2 per cent in the by-product oven. This means that it required 1.57 tons of coal to produce one ton of coke in the beehive oven, while in the by-product oven 1.40 tons were required, resulting in a loss of .17 tons of coal for every ton of beehive coke produced. As 55,606,828 tons of beehive coke were produced in 1917 this means that 9,453,000 tons of coal were wasted in that year.

In addition to this, by-product coke is a better blast furnace fuel than beehive coke and more pig iron is produced with a ton of by-product coke than with a ton of beehive coke. The chief cause of this economy is the uniformity of the by-product coke.

For years it has been the habit of coke makers to locate the beehive ovens near the mines. The coal from the adjacent mines was used in an unmixed form and, in the early days, when there was an abundant supply of good coking coal, it usually yielded a good coke under almost any condition. However, when the supply of good coking coal began to decrease and the demand for coke increased, the coals charged to the ovens were not always suitable for making good coke. In many cases, the producer, in an effort to increase his output, did not exercise a careful control over the production and preparation of the coke. The result was that coke varying in quality and size, particularly in percentage of fine or breeze, was received at the blast furnace.

Usually a furnace plant received its coke from several different plants, each of which coked a coal that differed in coking quality and hence, produced a coke of different character. As it is not common practice to keep more than a small supply of coke on hand, it was impossible to charge these cokes to the furnace in such a way that radical changes in coke quality would be avoided. This sometimes resulted in a hard coke being used for a short time, followed by a period of soft coke. Such variations in coke quality cannot tend towards good fuel economy or blast furnace practice, since coke represents twice the

bulk of the ore and stone. Moreover, furnaces using beehive coke do not, as a rule, screen the coke to any great extent and a fuel that varies in size from time to time is charged to the furnace. Every change in size has a tendency to aggravate the irregularity caused by change in quality.

By-product coke is usually produced at a plant under the control of the blast furnace interests and at a convenient distance from the furnaces. It is, therefore, possible for the furnace men and coke makers to coöperate to produce the best blast furnace fuel. As it is possible to ship to the ovens coal from any number of mines in different regions, coals of any desired type can be selected for making the coke, and as it is practicable to maintain a reserve supply of coal at the plant, the coal charged to the ovens need not be affected by transportation, irregularities or interruptions at the mines. This, together with the proximity of the ovens to the furnace makes the coke supply independent of the railroads for a short time at least. In the days of beehive coke it was quite common for a furnace to be banked on account of delay in coke shipment.

The mixing of coals makes it possible to use for coke making, coals that are not suitable for that purpose in the beehive oven. A coal of poor coking quality can be mixed with a good coking coal to produce satisfactory coke, or two coals opposing coking characteristics, neither of which would make good coke alone, can be mixed in the proper proportion and under correct conditions will yield a good coke. This is perhaps illustrated by Pocahontas and Eagle coals, neither of which in itself makes very good coke. These two coals can be mixed together with a small percentage of a good coking coal, such as the Pond Creek coal, and when they receive the proper oven treatment, will produce satisfactory coke.

The variation in coke quality when using the beehive product can be eliminated in by-product coke so that a fuel, uniform in size, character, cell structure and analyses, is charged to the furnace day after day. When coke of a variable quality is used in a blast furnace, the furnace man must either burn enough coke to take care of the worst possible conditions or be confronted with a furnace out of control at frequent periods and producing an off-grade of iron with tonnages below normal. In order to bring the furnace back to normal operation he is compelled to burn extra coke in large quantities. Each variation in coke quality necessitates a change in the operation of the furnace to maintain a good tonnage of the desired grade of iron.

By exercising the proper control over the factors affecting the quality of by-product coke, the furnace can be supplied with the coke most suited to its peculiar conditions. A coke that is satisfactory in one furnace may not give good results in another, so that it is necessary to determine by experience the best coke in each particular plant.

The efficiency of coke in the blast furnace may be altered by the kind of coals, their grouping and proportions, the oven treatment, and the screening of the coke.

After the coke that gives the best results in the furnace is found, it is necessary to keep uniform the factors controlling its quality.

When the same intelligently selected and grouped coals are thoroughly prepared, given the correct oven treatment; and the coke properly sized, day after day, a fuel that is uniform in character, sulphur and ash contents, and size, can be charged to the furnace. This eliminates perhaps the greatest variable in blast furnace operation and explains the good record of by-product coke.

The increase in the number of by-product coke ovens was slow but steady for many years. In fact, the development of the by-product oven industry has been influenced largely by the demand for by-products, as in the case of the first American plant, and the large number of plants constructed during the war. This slow change from the beehive to the by-product oven was due to a number of causes:

1. The high initial cost of a by-product coke oven plant.
2. The undeveloped condition of the market for by-products.
3. The adequate supply of coals suitable for making good coke in beehive ovens.
4. The feeling on the part of the furnace men that beehive coke was superior to by-product coke as a blast furnace fuel.

The economic wastefulness of the beehive oven in the production of coke and the loss of by-products has long been recognized. However, this waste was not eliminated on a large scale until it became necessary from a commercial standpoint.

The first by-product coke oven plant in the United States consisted of 12 ovens, with a capacity of 110 tons of coal per day. At the close of 1919 the number of by-product ovens was 10,519, with an estimated daily capacity of 90,000 tons of coal.

In 1893 the total production of by-product coke, all from a single plant, was 12,850, or 0.1 per cent of the total coke production for that year. In 1919 the estimated production of by-product coke was 25,000,000 tons, or 56.0 per cent of the total production of coke in the United States, making 1919 the first year in which the tonnage of by-product exceeded that of beehive coke.

Domestic Coke.

The coke breeze and the smaller sizes of coke that cannot be used in a blast furnace are used as boiler fuel around the plant, or may be sold to outside consumers. At the merchant coke plants, that is, plants producing coke for sale upon the open market, the production exceeds the demand for furnace and foundry fuel in some cases. The surplus, as well as the small sizes, are usually prepared and sold as domestic coke.

The use of coke for domestic and general industrial purposes has not been developed up to recently, on account of the available supply of other fuels, such as gas and hard coal and the ready market for coke in other fields. However, the growing scarcity of natural gas and hard coal has drawn attention to coke as a general fuel.

Domestic coke has been found very satisfactory for all fuel purposes where a little attention is given to its peculiar properties. It is smokeless and causes little or no dust in handling. The necessity of cleaning furnaces and flues is largely eliminated by the substitution of coke for soft coal. It has been estimated that 60 per cent of the smoke in large cities, where soft coal is generally used as domestic fuel, comes from the chimneys of residences. Hence 60 per cent of the smoke can be eliminated by the use of coke.

The results of the tests made by the American Radiator Company to determine the efficiency of domestic fuels showed that the efficiency of domestic coke was greater than that of either anthracite or of Pocahontas coal. In a series of tests at the University of Illinois, by-product coke led the list with an efficiency of 61.63 per cent, followed by gas coke with 56.22 per cent, anthracite coal with 51.93 per cent, Illinois coal with 48 per cent, and Pocahontas coal with 46.51 per cent.

Investigations by the U. S. Bureau of Mines also prove that coke can be burned in house heating furnaces much more efficiently than soft coal.

Recovery of By-Products.

The real crime of the beehive oven is the destruction or loss of products in the gas that are of great importance to the farmer, dye maker, wood preserver, roofing manufacturer, and the householder who burns gas. In 1918 the by-product coke ovens in the United States recovered by-products valued at \$66,967,027, as follows:

200,233,002 gallons of tar	\$ 6 364,972
423,515.8:6 pounds of ammonia	19,061,777
158,358,479 M cu. ft. of surplus gas	13,699,515
59,564,376 gallons of benzoi products.....	25,434,189
Other products, such as naphthalene, sodium prussiate, drip oil, etc	2,406,574

The average value of by-products from each ton of coal coked in a by-product oven was \$1.85.

Assuming that by-products of equal value could have been obtained from the coal coked in beehive ovens in that year, the loss of by-products amounted to \$88,108,100.

The moment that the gas distilled from the coal is subjected to cooling, some of the hydro-carbons begin to condense and form tar. This tar is a black, evil smelling liquid of a very complex composition, yet from it are obtained all of the colors of the rainbow, substances with a fragrant odor and others of an asphyxiating nature; healing drugs and deadly poisons. It has been estimated that it contains more than 200 chemical compounds.

All of the ammonia was formerly removed from coke oven gas by washing with water. The resulting solution, known as weak liquor, was distilled to produce concentrated liquor of various grades of ammonium sulphate. In recent years many plants have installed apparatus to produce sulphate by the direct or semi-direct method. In this process the gas is passed through a solution of sulphuric acid which combines with the ammonia to form ammonium sulphate.

Benzol is recovered from the gas by absorption in a petroleum oil. This wash oil has a high boiling point and the benzol, together with toluol, xylol, and naphthalene are separated from it in the form of light oil by distillation.

Coke oven gas also contains some cyanogen, which is removed at several plants. In some cases it is taken out before the ammonia washers and in other cases after the benzol scrubbers. The finished product is the same in both systems.

Use of By-Products—Tar.

The greater portion of the tar recovered at by-product coke plants is distilled as a preliminary to the production of dye stuffs, drugs, oils, and other useful compounds. The distillation may be carried out only far enough to remove the water and a portion of the lighter oils. This so-called refined tar is used for water-proofing purposes, in the manufacture of roofing materials, and as a road binder. Usually a complete distillation is made and the following fractions are secured:

1. Light oil.
2. Middle oil.
3. Heavy oil.
4. Pitch, the residue.

Tar, being a product resulting from progressive condensation, yields itself well to fractional distillation for the separation of these fractions.

The volume of the first fraction is from 1 to 4 per cent of the volume of the original tar. The light oil after re-distillation and washing yields benzol, toluol and solvent naphtha, together with small quantities of phenol and cresols. These products may be used commercially as such, or may be treated to produce such intermediate chemicals as nitro-benzene and aniline salts and oils, or refined products like trinitrotoluene, diphenylamine, dyes, hydroquinone, and various drugs and medicines.

From the middle oil fraction are obtained phenol, cresols, naphthalene and some creosote oil. These are used to produce carbolic acid, lamp black, dyes and disinfectants.

From the heavy oil fraction are secured anthracene, creosote oil, and some naphthalene. Anthracene is the source of alizarin used in the manufacture of alizarin dyes. Most of the creosote oil is obtained from this fraction. The demand for creosote oil as a wood preservative has been the most important factor in the development of the American tar distillation industry. Eighty per cent of the total production of creosote oil is used for treating railroad ties.

Pitch is the residue remaining in the still after the volatile oils have been distilled off and the volume is from 50 to 75 per cent of that of the original tar. The quality varies from a soft viscous grade to hard pitch. The softer grades are used as binders in pavements, water-proofing materials, coating for pipes, and as binders in fuel briquettes. The harder grades are used in the manufacture of core and insulating compounds, electric carbons, and clay pigeons. Pitch can also be used as fuel in a crushed or pulverized form.

Ammonia.

The finished concentrated ammonia liquor produced in by-product plants may be in the form of crude concentrated liquor, aqua ammonia or anhydrous ammonia.

Crude concentrated liquor is merely the weak liquor, concentrated without purification. It may be used in the manufacture of soda ash or in the production of other ammonium compounds.

Aqua ammonia is made by absorbing the purified ammonia gas in distilled water. Much of it is used for cleaning purposes. Household ammonia is a dilute form of aqua ammonia.

Anhydrous ammonia is produced by liquifying the purified ammonia gas in a compressor. It is used in refrigeration and the manufacture of artificial ice.

From these primary ammonia products are manufactured a number of secondary compounds, quite commonly known. The principal ones are ammonium carbonate and bi-carbonate, used as leavening agents in baking powders to reduce the amount of yeast; ammonium chloride or sal-ammoniac, used in electric batteries and for various technical purposes; and ammonium nitrate, used in the manufacture of explosives.

Ammonium sulphate, produced by the direct and indirect systems does not differ materially. Its greatest use is in the manufacture of fertilizer, as it is a very important carrier of nitrogen. Its nitrogen acts quickly and is not readily dissolved out of the soil.

It has been demonstrated that the production of wheat on average soil, producing normally about 20 bushels of wheat per acre, will be increased 8 bushels by applying 100 pounds of ammonium sulphate to each acre.

Benzol.

Previous to the outbreak of the European war, practically all of the benzol recovery plants in the United States were operated by the Semet-Solvay Company, and much of the crude light oil produced by those plants was used for gas enrichment purposes. This condition has since been radically changed.

The crude light oil is usually re-distilled and washed with sulphuric acid and an alkali to separate the finished pure products—benzol, toluol, xylol and solvent naphtha.

During the war large quantities of these products were used in the manufacture of explosives, such as picric acid from benzol, trinitro-toluol from toluol, and trinitroxylol from xylol.

The demand for explosives ceased with the end of the war and, as the benzol production is in excess of the requirements of the chemical industries, large quantities are now being used as motor fuel. This motor fuel is a mixture of benzol, toluol and solvent naphtha. Its fuel value is about 20 per cent greater than that of ordinary gasoline. By adjusting the carburetor it is possible to use benzol unmixed with gasoline, but it is the general practice to mix it with gasoline.

Benzol has been used for years in Germany as a motor fuel. During the war Germany was for a time completely cut off from a supply of mineral oils and was compelled to depend upon benzol.

Benzol products are also used in the manufacture of paints, varnishes and leather substitutes.

Coal Tar Products Industry.

Many of the compounds separated by the distillation of coal tar, as well as the benzol products, are used in the manufacture of dyes. This industry has been developed from a modest beginning by gradual stages, over a period of many years. The first coal tar dye was a violet, produced accidentally by Perkins, an Englishman, in 1856. The importance of this discovery was appreciated and other dyes soon followed.

The Germans apparently recognized the great possibilities in the development of the dye-stuff and allied industries and labored to secure world-wide supremacy in this field. By continual scientific research they added to their knowledge of the art, and by developing efficient methods of manufacture they established the industry upon a firm efficient basis.

The elimination of the beehive oven in Germany supplied the industry with raw materials. However, the demand outgrew the home supply of coal products and crude materials were imported from England in exchange for the finished dye-stuffs, thus discouraging the development of the industry on a large scale by England, the logical competitor of Germany.

This highly developed German industry was backed by adequate capital and assisted by the Imperial Government in every possible manner. This strength, together with coöperative methods, such as the interchange of foreign trade data, secured by the various firms, made the German industry almost immune from successful competition by foreign manufacturers, unprotected by a tariff.

The German Government foresaw the great military value of the dye-stuff industries. It realized that the great factories filled with complicated apparatus and the army of skilled and highly trained workmen, chemists, and engineers, could be changed over night from the production of dyes for the peaceful arts to the production of powerful military explosives. This industry contributed very greatly to the power of Germany as a menace to modern civilization for more than four years, although cut off from the rest of the world and dependent chiefly upon her own resources, by making it possible for her to literally manufacture explosives from the air and earth.

The backwardness of America in the development of the coal products industry was not due to a lack of ability or scientific knowledge, but to the monopoly possessed by the Germans. German dyes of known value could be secured at a lower price than American dyes and consequently capital was not interested to any great extent in the development of a home industry unprotected by a tariff.

However, long before the European war, several pioneer American firms, assisted by a few far-sighted consumers, laid the foundation of an American coal products industry, in spite of the tremendous odds against them. They produced a few dyes and intermediates, as well as other coal products in limited quantities, and with the support of their loyal customers were able to survive until the outbreak of the war. Then conditions created by the war made it

possible for them to expand and increase their output.

The dye-stuff and allied coal products industry is very complicated because of the great number of different products, comparatively small in volume, and the complex chemical processes involved. It is necessary to utilize every by-product from each step and to manufacture a vast number of materials, which are very closely related to each other, to carry out each process on the largest possible scale and reduce waste to a minimum. Furthermore it is connected directly with the manufacture of mineral acids and alkalies, which are used in large quantities in almost every phase of the industry.

Every operation must be carefully controlled and carried out under skilled supervision in specially constructed apparatus. A moment's hesitation in performing some simple function, or a slight increase in pressure or temperature may result in the loss of much valuable product, or perhaps an unfortunate explosion and fire, causing the loss of life and destruction of costly machinery.

Coal tar dyes may be divided into eight general classes, as follows:

1. Sulphur dyes.
2. Tanning dyes.
3. Acid dyes.
4. Vat dyes.
5. Mordant dyes.
6. Dye salts dyes.
7. Albumin dyes.
8. Developing dyes.

The dyes in these different groups are manufactured by different processes and do not possess the same qualities. Each group is suitable for use on certain fabrics, although the colors of the dyed material may be similar.

The manufacturer of virtually all of the dyes and other coal products, such as drugs, explosives, and perfumes, involves the use of a number of intermediate products. Many years of scientific research and experimental development were necessary to make possible the successful production of these intermediate and finished products on a commercial basis. For example, in the manufacture of phenol or carbolic acid from benzol, there are five chemical reactions and at least 10 different chemical operations. It is necessary to carry out each step in the most efficient manner, as an avoidable loss of 1 or 2 per cent in each operation would make the yield of phenol so small that the process would be unprofitable.

The number of intermediates utilized in the dye industry in Germany and Switzerland before the European war has been estimated to be at least 400.

It is evident that the American coal products industry could not be the fruit of a few months effort. Nevertheless great progress has been made since 1914, when many industries were almost paralyzed after the available stocks of German dyes were exhausted. In 1914, \$7,241,000 worth of dyes were imported into this country, while in 1917 our exports were valued at \$11,709,000.

Heating Furnaces and Annealing Furnaces

Powdered Coal—Effect of Fineness of Grinding Upon Successful Operation of Heating Furnaces—Economical Conditions for Using Powdered Coal—Formula for Powdered Coal Cost.

By W. TRINKS.

PART XVII.

THE advantages of gas fire or of oil fire compared to coal on the grate, including stokers, are well known. They include inexpensive transportation of fuel to furnaces, uniformity of temperature over hearths of considerable size, a small amount of excess air (which means small oxidation loss), better controllability, quicker heating up. On the other hand, the uncertainty of supply of natural gas and the high price of oil offered an inducement to couple the advantages of gas fire with the low price of coal. To secure these advantages, the coal must be brought into such a form that it can be burnt over and around the material which is being heated; and this requirement can only be met by finely powdered coal.

The words "finely powdered coal" were used advisedly because the early attempts to use powdered coal were failures due to the coarseness of the powder. The troubles which beset the user of powdered coal were reduced as the fineness of the powder was increased. A brief study of the reasons underlying this condition will pay. Powdered coal is a solid and not a gas. Oil is vaporized while it is in the furnace, but coal cannot be gasified with the exception of the volatile matter in the coal. The circumstance that

volatile matter is gasified in the furnace causes coal powder made from highly bituminous coal to burn more readily than coal powder made from semi-bituminous coal. This statement should not be misconstrued into the belief that use of a highly volatile coal permits coarse grinding.

The most desirable fineness of grinding is determined by two conflicting conditions: the finer the coal powder the less is the cost of heating (repairs and shutdowns included), but the greater is the cost of pulverizing. While the general principle is laid down in a few words of the preceding sentence, the numerical calculation of the cost of operation and of the cost of pulverizing (both as a function of fineness) is almost impossible, at least at the present time. In spite of this condition, a discussion of the important influences will be of value.

Coarse coal powder burns slowly. Unburnt glowing particles fall on the steel which is being heated, without being completely burnt, or are swept into the outlet flue, or pass out around the door openings, or else strike against the brick work of the furnace. Any one of these actions involves a loss either from increased fuel consumption, or else from scaling due to excess air (introduced for the purpose of securing

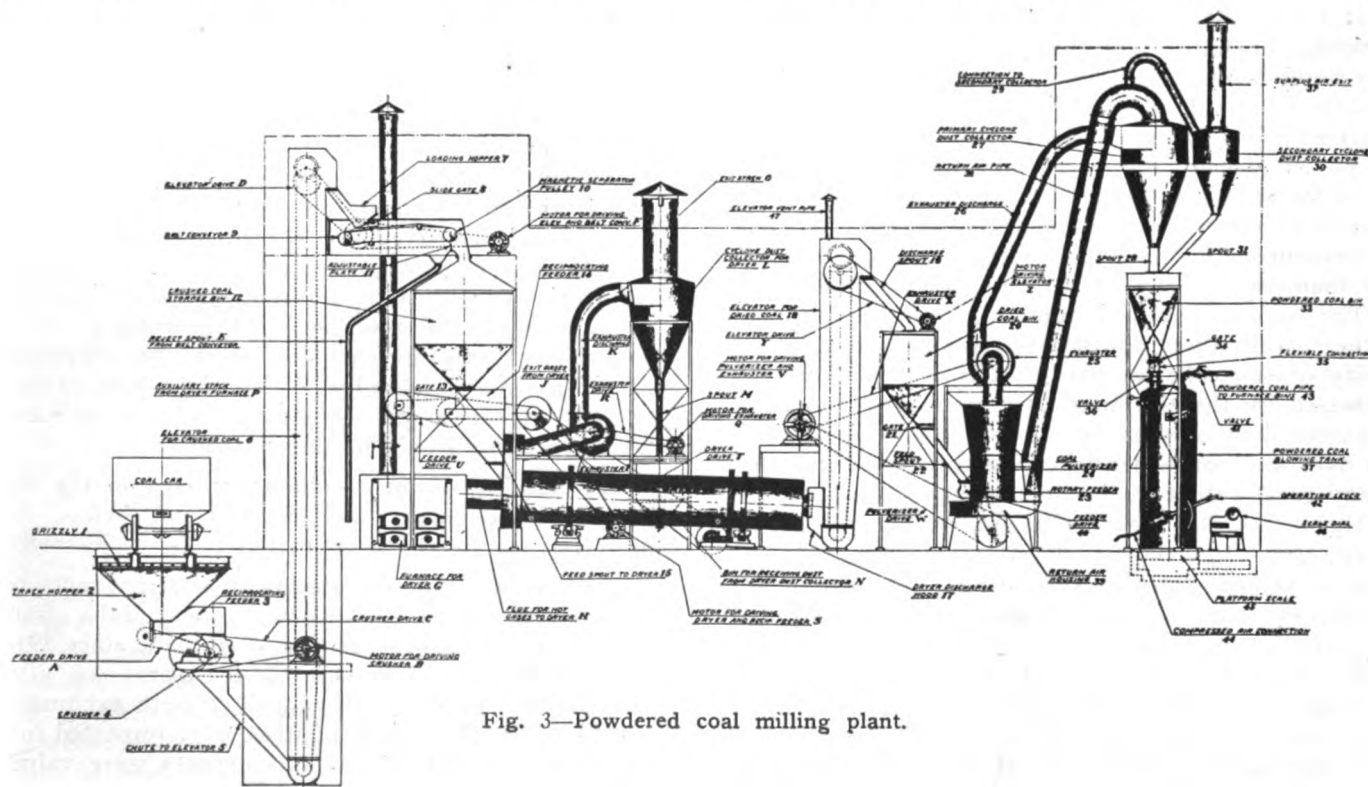


Fig. 3—Powdered coal milling plant.

quicker combustion) or else from damage to the brick work.

The latter action is a very unwelcome accompaniment to the use of powdered coal and is particularly annoying with coarsely powdered coal. The reason for the quick cutting away of the brick work is, in fact, a summation of several reasons. Heavy, coarse particles do not change their course quickly with gas or air currents, but tend to move in straight lines. Hence, they are projected against the brick work rather than pass around curves with the gases. As soon as the white hot coal particles strike the brick work they stick, and the ash forms a flux with the firebrick, lowering the melting point of the latter and producing fusion. Bridgewalls, sidewalls, and roofs cannot be made to last the week out with coarse coal powder. Finer grinding reduces the trouble for two reasons. First, the particles are burnt before they strike the wall, and second, the light weight of each particle causes it to float in the current rather

find that the influence is twofold. First, it takes a great deal of power or work units to grind the coal to an impalpable powder, and second, fine grinding re-

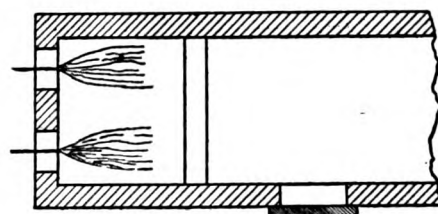


Fig. 113.

quires the installation of a large grinding mill, because air currents will carry off heavy coarse particles if the mill is loaded to capacity. This fact furnishes the reason why careful engineers install excess capacity in grinders. As a rule, the money for the extra investment is well spent, because it cuts down the first cost and the maintenance cost of the furnaces. If a grinder is loaded to capacity, the powder is not as fine as it should be, unless an individual air separating outfit is installed which allows only the finest powder to go to the furnace and returns the coarser powder to the grinder.

Taking for granted that powdered coal of the above specified fineness is a desirable fuel, we are still confronted by the question: When does it pay to use powdered coal, and when does it not pay? That question will answer itself step by step through a study of the conditions surrounding the use of powdered coal and connected with it. To that end figure 111 is presented. It represents all of the equipment necessary in the grinding room. Quigley equipment has been shown, because the drawing issued by the Quigley Furnace Specialty Company is spread out to show the equipment in a clear and direct manner. Equipment furnished by other companies requires practically the same number of machines and apparatus. One glance at figure 111 is enough to convince anyone that powdered coal will never do for the user of a few small furnaces, but that its use is limited to larger plants. The line between the two is not sharply drawn, as will be seen from figure 112 which was adapted from "Engineering," July 11, 1919. The latter illustration teaches that the smallest size of

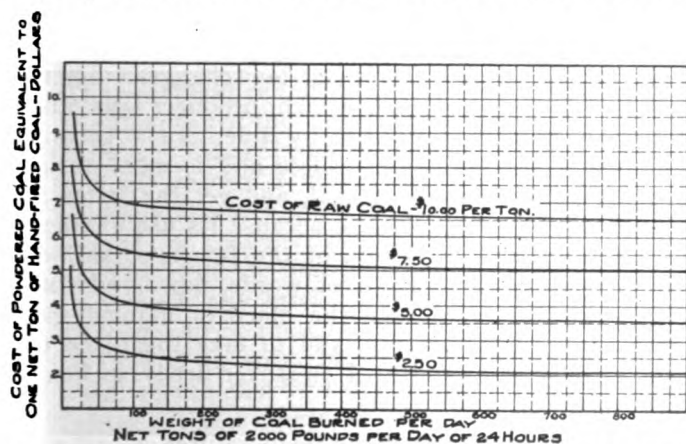


Fig. 112—Cost of powdered coal for performing the same work as 1 ton (2,000 pounds) of hand-fired coal. Assuming 33 1/3 per cent saving in fuel by the use of powdered coal and as an offset against the value of the fuel saving the cost of preparation and burning powdered coal has been added.

than to be thrown against the walls. A critical reader may contend that both reasons are one and the same, because the burning of the particle before it has traveled sufficiently far to reach a wall, causes a very great reduction in the mass, the ash being the only solid substance left.

The fineness of grinding which just barely avoids trouble obviously depends upon the volatile matter in the coal, upon its ash content, upon the design of the furnace, and last but not least, upon the methods of injecting the mixture of coal powder and air. It is, therefore, no wonder that practical figures vary. The fineness which is now considered desirable is expressed by the following specification: 95 per cent of the powder must pass through a standard 100 mesh (to the inch) sieve, and 85 per cent must pass through a 200 mesh sieve. The specification is very simple and direct; standard sieves are easily obtainable, and yet few users of powdered coal make a practice of checking the fineness at regular intervals.

Turning to the other end of the problem, namely the effect of fineness upon the cost of pulverizing, we

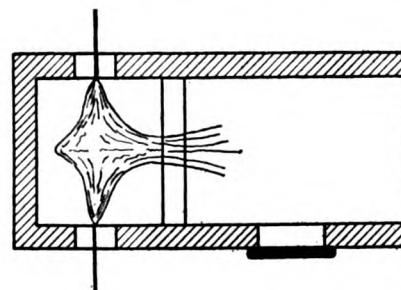


Fig. 114.

plant for which it pays to use powdered coal is the smaller, the higher the cost of coal in proportion to the cost of machinery and labor. Figure 112 is illus-

trative only and should not be used indiscriminately, because it was based on equipment costs at the time when they were in a state of rapid changes.

For a more accurate figure of the cost of powdered

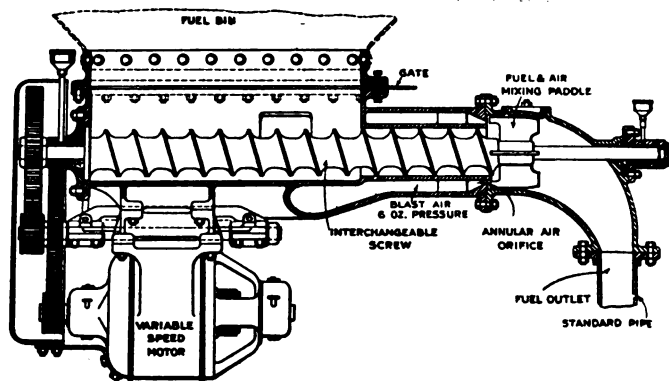


Fig. 115.

coal, we must take into consideration the following:

1. Cost of plant involving price of labor at the time of building.
2. Cost of operation involving price of labor at the time of use.
3. Cost of coal involving price of labor at the time of use, and cost of transportation.

On the basis of data furnished by the Fuller Engineering Company, I have built up the following formula, which gives the cost of a short ton of powdered coal delivered in the furnace bin:

$$E = 1.05 A + \frac{2200 L \sqrt{C}}{B} + L_1 \left(\frac{4}{\sqrt{C}} + .14 \right)$$

In this equation

E = The cost of a short ton of powdered coal at the furnace, dollars.

A = Cost of raw coal, dollars per short ton, on the siding.

L_1 = Cost of common labor, dollars per hour at time of grinding coal.

B = Weight of coal actually pulverized per year, short tons.

L = Cost of common labor, dollars per hour, at time of building and of installation of plant.

C = Rated capacity of pulverizing plant, short tons per day of 24 hours.

In the equation the figure 1.05 takes care of the fuel used for drying, and for generating power used in crushing, powdering and conveying. The factor 2200 in the second term represents interest, depreciation (but not maintenance), insurance, and taxes, based upon a yearly charge of 12½ per cent of the total cost of drying, pulverizing and conveying equipment, bins, buildings, and foundations. If any other rate D is used for the sum of the interest, depreciation, etc., multiply the factor 2200 by the ratio $D/12\frac{1}{2}$. The term C in the second and in the third term indicates that the cost of the plant does not go up as fast as the capacity and that the labor cost of pulverization goes down as the size of the plant increases. The factor .14 represents the cost of repairs and of maintenance.

The equation is substantially correct for average conditions. It needs modification if the cost of installation is unusual, due, for instance, to excessive cost of real estate, or of difficult foundations.

From the equation for the cost of powdered coal and from the curves in figure 112, it follows that the cost of preparation is quite high if the plant is small. After a study of these figures, one is tempted to ask why we should ever use powdered coal. Oil will do for small plants and producer gas (in some form or other) will do for large plants. The answer is that many furnaces were designed for the use of natural gas or for the use of coal on the grate. Mills or forges were erected around these furnaces, and failure of the supply of natural gas, or the wish to either improve furnace operation, or to do away with the manual distribution of coal to the individual furnaces, made a change necessary. In most cases the use of producer gas would have meant a rebuilding of the furnace, the installation of regenerators or recuperators, and a serious interruption of service, and perhaps trouble from water in the regenerators, while the use of powdered coal meant but few changes. There are plants in existence in which producer gas and powdered coal are used side by side. In a certain plant, the producer gas costs less and is more satisfactory than the powdered coal, and yet the latter is used in some of the furnaces, because its use avoided the cost of rebuilding some of the furnaces, and of rearranging the mill. In other words, powdered coal is the logical fuel to take the place of natural gas where the latter is waning, and to take the place of coal on the grate (hand fired or stoker fired), in heating furnaces of large plants.

Powdered coal gives flame temperatures which are high enough for any heating furnace, and gives these temperatures without regeneration or recuperation.

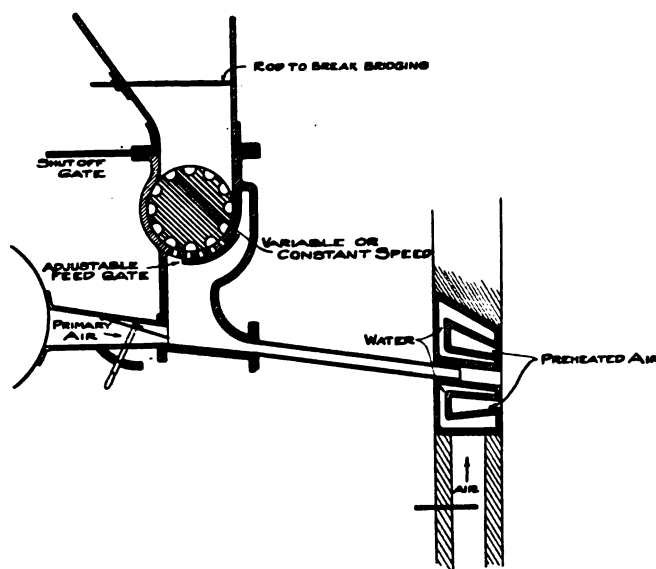


Fig. 116.

As a matter of fact, either one of these heat saving appliances is undesirable in connection with powdered coal, on account of the filling up effects of the ash. It is the latter effect which has delayed the introduction

of powdered coal for open hearth furnaces and has, in several places, caused the abandoning of powdered coal after it has been used with such furnaces. The absence of the heat saving features detracts from the value of the statement of powdered coal enthusiasts that that fuel avoids the succession of heat losses which reduce the available heat in producer gas to a considerable extent, while, with powdered coal, the actual solid fuel is both gasified and completely consumed directly within the chamber to be heated. Several continuous furnaces with powdered coal which were originally equipped with steel tube recuperators have been rebuilt and the recuperators have been removed.

If regenerative apparatus is to be successful with powdered coal, the latter must contain very little ash (less than $4\frac{1}{2}$ per cent), the grinding must be extremely fine, and the regenerators must be of open construction, easily accessible for cleaning, and without dead pockets.

A problem which arises quite often in connection with powdered coal is that of the changes which are necessary in order to adapt a furnace to that fuel. That problem cannot be solved without knowledge of the fineness of the coal powder and of the type of the burner. Coarse coal and imperfect mixing of coal and air require a very long combustion space. With average fineness and with furnaces using 800 to 2,000 pounds of coal per hour, a length of $4\frac{1}{2}$ ft. to $5\frac{1}{2}$ ft. suffices, but the flame should be carefully directed to not touch any brick work in less than that distance. At the end of the combustion space there is a bridge wall, and the space between the burner and the bridge wall serves also as a deposit for the heaviest ash particles. The burners are arranged either as shown in figure 113 (which shows the usual arrangement) or as shown in figure 114. The latter arrangement is claimed to offer the advantage that the two jets of flame impinge upon the brick work. Much of the mystery which surrounded furnace design for powdered coal in the early days, has disappeared with

finer grinding and with better flame control.

With the present state of the art, flame control is very good, if variable speed screws are used. Figure 115 (Locomotive Pulverized Fuel Co.) shows a feed screw and mixer which allows a great range in quantity of fuel fed in unit time and effects a thorough mixture of coal dust and air. In those burners which work without a feed screw the flow of coal is usually pulsating; the coal comes in gulps, and combustion is irregular. It must, however, be admitted that the pneumatic burners (without a feed mechanism) are very much simpler and cheaper than the mechanical feeders and that they are probably good enough for small furnaces.

Not all mechanical burners are good. Some of them neglect the principle that the coal must be fed in an absolutely uniform stream. In this connection, attention is called to figure 116 which shows a burner and feeder designed and used by a large steel company. At the lighter loads, only one pocket delivers coal dust at intervals, and the feeding is not as uniform as it should be.

Flame intensities and flame lengths can be varied with powdered coal in the same manner in which they are varied with oil or gas. Thorough pre-mixing of coal and air produces comparatively short (4 to 7 ft.) intense flames, while absence of pre-mixing produces long lazy flames of comparatively low temperature. The latter are particularly desirable for annealing furnaces, while the former are used in high temperature heating furnaces.

In almost all designs of powdered coal burners, air is admitted in two stages. The reason is that part of the air is used for conveying the fuel from the feeder or from the supply pipe to the burner, and for injecting and scattering the jet of coal dust. The greater part of the air needed for combustion, however, is supplied right at the burner, so that its volume and distribution can be varied to regulate the flame length and the quality of the flame without affecting the regularity of the fuel bed.

Electric Heating in Steel Wire Manufacture

Comparative Cost Statistics Taken at the Plant of the Halcomb Steel Company on Drying Ovens Heated Electrically and Similar Ovens Using Coke and Steam.

THE application of electric heat to the process used in making steel wire has given such excellent results and is so economical of operation that it should be of interest to all plants where wire drawing is done.

In the manufacture of steel wire the rods as received from the hot rolls are pickled in acid to remove the scale, dipped in lime-water to neutralize the excess acid, and then baked, to drive out the "acid in the steel," the amount of baking depending on how small the wire is to be drawn. If it is to be drawn only one or two holes, a short bake is enough, but

for five or six holes the stock must be baked for several hours to withstand the severe drawing. The wire may be, in some cases, additionally heated to dry off grease or oil, or for a low anneal.

At the plant of the Halcomb Steel Company, at Syracuse, N. Y., where the following operation figures were obtained, there are two electric drying ovens, using General Electric apparatus, one 16x6x6' with 96 kw connected, used for drying off the wire, at a maximum temperature of 600 degrees F., the other 40x6x6' with 234 kw for drying "acid in the steel," the wire being in the oven from one to 10 hours at an average

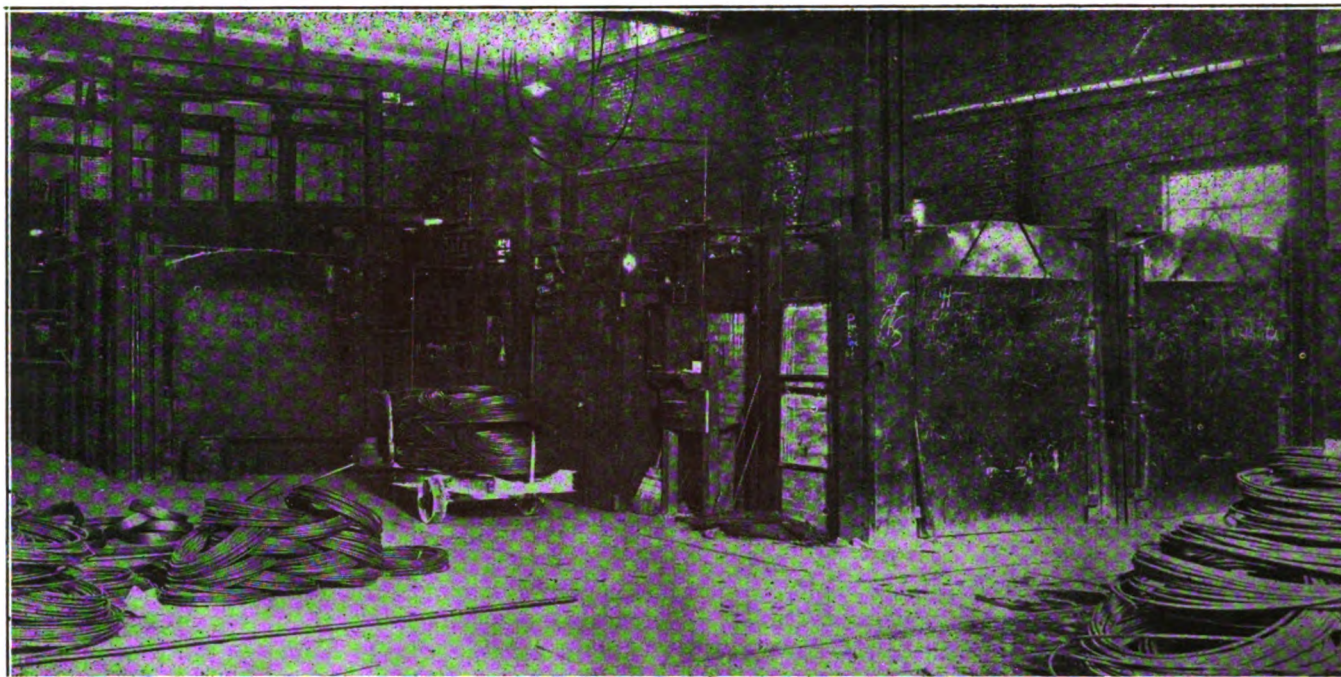


Fig. 1—Typical installation of wire baking ovens equipped with General Electric heating units and automatic control. The furnaces shown are at the plant of the Halcomb Steel Company, Syracuse, N. Y.

temperature of 350 degrees F. Coke and steam heated ovens are also used to do the same work, thus it is possible to obtain comparative operation costs.

In spite of the fact that the cost of electric power is higher than the fuel cost for similar ovens, when the total cost of operating the ovens was considered, as shown by the data outlined below, a decided economy was shown by the electric oven.

The following data shows the cost of operation of

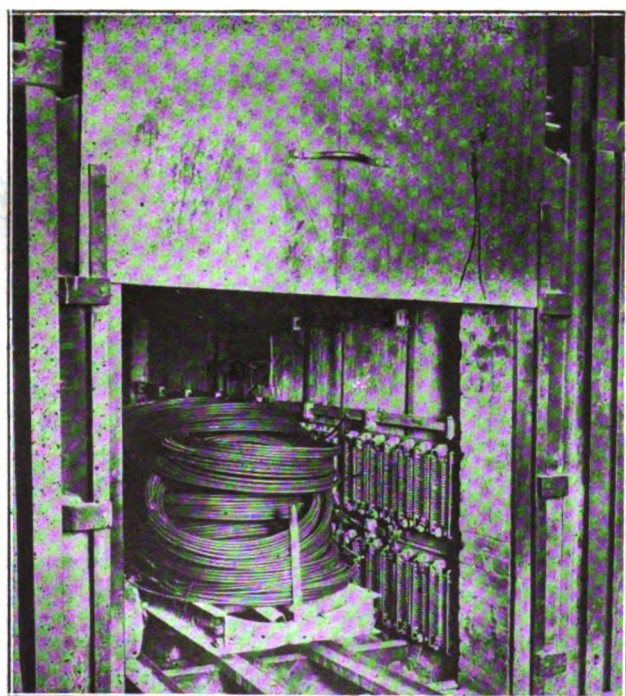


Fig. 2—Interior view of wire baking oven showing heating unit installed in oven 5' 6" wide, 16' 6" deep and 6' 4½" high. Maximum operating temperature of 600° F.

the electric and coke oven for a considerable period of time on the ovens used in drying grease and oil from the steel, with normal production, and also the figures applicable if full production had been possible. The work of electric power in these tables is figured at \$.95 per kw hour:

ELECTRIC	PRODUCTION	
	Normal	Max.
Cost of power net ton steel	\$ 5.087	\$1.19
Annual charges per net ton	7.839	.727
Total cost per net ton	\$12.926	\$1.917
COKE		
Cost coke per net ton	\$.921	\$.171
Annual charges per net ton	21.368	1.983
Total cost per net ton	\$22.289	\$2.154

This shows that as actually operated the coke oven cost \$22.289 per net ton against \$12.926 per net ton for the electric, a saving of \$9.36, while if operated at maximum capacity there would be a saving of \$0.237 per ton in favor of the electrically-heated oven. The efficiency of the electrically-heated oven as actually operated amounts to 3.75 pounds per kw hour, or 535 kw hours per ton, the maximum figures being 16 pounds per kw hour, or 125 kw per ton.

The figures on the operation costs of the kiln for drying "acid in the steel" also shows a greater economy in the use of the electric oven:

ELECTRIC	PRODUCTION	
	Normal	Max.
Cost power per net ton steel ..	\$.787	\$.515
Annual charges per net ton	.648	.187
Total	\$ 1.435	\$.702
COKE		
Cost coke per net ton steel	\$.253	\$.146
Annual charges per net ton	1.766	.510
Total	\$ 2.019	\$.656

Showing the coke oven as actually operated, cost-

ing \$2.019 against \$1.435 per net ton, for the electric or a saving of \$0.584 per net ton in favor of the latter. If they were operated at maximum capacity there would be a cost of \$0.406 per net ton higher for the electric than for the coke oven. As operated the efficiency of the electric oven is 24.1 pounds per kw hour, or 85 kw hour per ton, while the maximum production figures would be 36.8 pounds per kw hour, or 54.4 kw hours per ton.

These figures show that the electric oven can actually be operated cheaper than the coke except in one case where it showed a cost of 7 per cent higher. However these figures take no account of increased perfection, and duplication of results of the finished product due to the perfect temperature control, whereby the operating temperature can be quickly changed when desired. Nor do they take into account the freedom from delay due either to the difficulty of ob-

taining coke at the ovens, or the slower treating of the oven from cold to start of work.

This particular plant is operated on a quality basis, therefore speed is of secondary importance; however, should speed of operating be important the value of the electric oven would still exist, since the uniform distribution of heat gives a rapid rise to maximum heat, and the perfect control of temperature makes it possible to maintain the maximum temperature without danger of overheating. The use of electric heat has not only increased the capacity of the ovens, but produces finished work with no rejections.

In another plant where the wire is not drawn so small, and consequently such a long baking is not necessary, the electric oven installed has an efficiency of 110 pounds per ton on comparatively long bakes at 400 degrees F.

Turning Rolls in Sheet and Tin Mills

**Selecting a Roll Turner—What a Roll Turner Should Know—
Crossing Rolls—Using the Straight Edge—Hardening Face of
Rolls—Pressing Rolls.**

By W. H. MELANEY.

IN all mechanical processes, no matter what trade is considered, the mere act of doing things a certain way because that is considered the correct way to do it, is considered the proper thing to keep in the mind of the apprentice without bothering to explain to him the proper or scientific reason therefore.

This unfortunately is responsible for many persons becoming fairly proficient in the mechanical execution of their adopted trade without having any initiative that would lead them to consider other or more effective means of producing the same result. The result is that such inventive genius as they may possess remains dormant because they have not sufficient knowledge to permit them to make deductions from the effect they find in evidence, back to cause, or to reason from cause to probable effect.

As a consequence, they will remain either as skilled or mediocre mechanics while some more curious individual, but with less brain power, perhaps, will succeed in getting placed in a foreman's capacity over them. Why does this happen? Because the man so favored was not content to simply know the proper way to do any particular thing, but why that was the proper way. He was then in a position to adapt his knowledge to any variation in conditions that might occur in his own particular surroundings and he would appear brighter in comparison than the more brainy man who did not possess this adaptability and by using fair judgment and keeping skilled men under him he produces results for which the skilled man perhaps was directly responsible but for which the foreman alone receives the credit. This is the usual condition that exists in fact, no matter how unfair it may seem in theory, and the mechanic, if he thinks about it at all will ascribe the foreman's tenure

of his position to pull when it was only ability to adapt himself to circumstances.

Selecting a Roll Turner.

This brings us to the main matter in hand, the selecting of a roll turner to be placed in charge of that part of the mill operation.

Every mill manager will agree that no matter how well equipped the mill and no matter how fortunate they may be in possessing a skilled organization in every other department of the mill, if they do not possess a skilled, resourceful roll turner, all their efforts to produce good marketable product comes to naught. Yet how many managers consider when hiring a roll turner, anything more than his years of experience on that one particular line and his ability to do creditable mechanical work on the roll lathe, notwithstanding the fact that in no two mills are conditions exactly the same and the man who perhaps made good in one mill is a miserable failure in another, simply because he was not gifted with adaptability along with his skill. Therefore, the most desirable quality in a roll turner beyond just sufficient mechanical proficiency to do the work, is reasoning power rather than exceptional skill.

Unfair Discrimination.

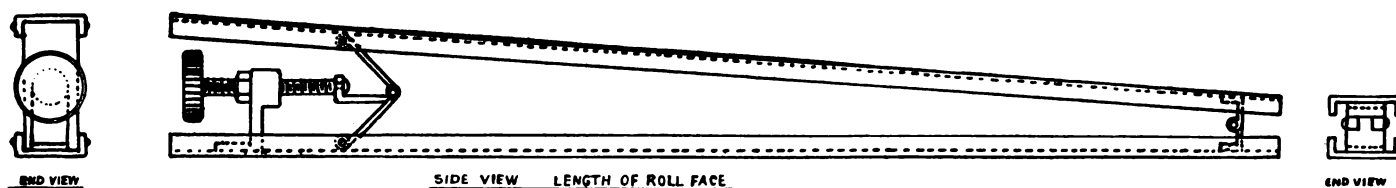
Having selected the man for this position who has a scientific knowledge or at least the reasoning power to know why the prevailing conditions in that mill are right or if they are not right why they are wrong. It follows as a matter of course, he will be able to stipulate the necessary change in conditions to make them right and right here is where education and especially scientific education counts. Here also is

where the roll turner is discriminated against. He holds one of the most responsible positions in the mill, because the quality and quantity of the entire output of the mill depends on his knowledge and skill. The rollers, no matter how skilled they may be, cannot produce satisfactory results unless the rolls are properly designed and turned, a condition for which the roll turner is held strictly accountable, and yet the roller receives much greater compensation and generally more consideration than the roll turned. Why should not the roll turner, if he is producing the goods, be placed on a parity with the roller?

What a Roll Turner Should Know.

A roll turner, and when I use that term I mean the man in charge of that department, should not only know how to turn the rolls to produce a given sheet but should know all the conditions under which the rolls must operate.

He should be thoroughly posted on the characteristics of each roll before and after it goes into service. He should also know the depth of the chill, whether it is of a mild or hard character, whether any grey specks are showing on the face, whether it is free from pin holes or other blemishes, in order that he may know what particular grade of sheets it is best fitted to roll.



Adjustable straight edge holder for crossing rolls with straight edge.

If common or galvanized sheets are wanted, then he can use rolls that would never do to roll automobile or other high-grade sheets and in the interests of economy he should keep such rolls for this purpose, using the perfect rolls for the production of high-grade work.

This means he should keep a perfect card record of every roll in use so that he can see at a glance what condition any roll is in and be able to use his judgement as to what use it is best adapted.

Having been informed of the kind of orders that will be rolled on each mill, he will turn the rolls for that particular work.

Crossing Rolls.

It will depend, of course, on the width of the sheets, whether wide or narrow, how much cross or concavity he puts in the rolls, the wider the iron the less cross required, also on how long the sheets are to be rolled, as the longer the pack the quicker the rolls will heat up.

It also depends on whether the concavity is turned into the roll until it fits a straight edge placed with a certain angle across the face of the roll, or whether it is turned in to fit a straight roll placed on top with a given amount of cross or angle, as the conditions are

not the same, although many roll turners believe they are.

It is a fact that a straight edge, angled across the face will require more concavity in the face of the roll before it fits, than is produced when it is fitted to a straight roll, crossed or angled the same amount. This gives rise to much discrepancy in the amount of cross a roll must have to properly roll a given size of sheet and when a given cross is specified it is imperative to know whether it is to be fitted to a straight edge or a roll, and this is why different mills apparently use different amounts of cross for doing the same work.

Using a Straight Edge.

If a straight edge is used, assuming for arguments sake that a narrow edge amounting to a line is obtained, then you have a perfectly straight line that must be angled across the face of roll (and in the example we will assume that all the concavity is to be turned in one roll) and the roll hollowed out until the straight edge fits along its entire length.

Another fact that must not be lost sight of is that the smaller the diameter of the roll, the less cross it will require for the same concavity and using a small diameter roll to illustrate the point, we will assume

that a 23-in. diameter roll is to be crossed three inches, all the cross to be in one roll. Then if the straight edge is angled $1\frac{1}{8}$ in. from a straight line and the roll hollowed out until it fits, the depth of the hollow at center of roll will be practically equal to the thickness of a 25-gauge sheet, and this same hollow roll, if fitted to a straight roll placed on top would require the roll to be crossed a little more than 3 inches. These sizes are used because the data is available, but the larger the diameter of the rolls, the less the difference will be between turning the cross to a straight edge or topping to a roll, although even in the case of 28 and 30-in. diameter rolls, it is considerable.

The straight edge is a perfectly straight line, while if a straight roll is used to fit into the hollow one, you are fitting into it a helix or spiral line running around the surface of the roll, the amount of the cross, and of course the smaller the diameter of roll, the greater the convexity of this spiral line. Therefore, you would be fitting into the concave roll, a convex edge.

If both rolls are concaved then half is placed in each roll, one being turned to an angled straight edge. The second roll roughed out to a straight edge at same angle and the other roll placed on top and crossed until they roughly fit, then the second roll is

fitted perfectly to the top roll. And you will then find that the top roll is crossed more than double what the straight edge was crossed to turn in the rolls this same concavity.

Pairing Rolls Up.

The rolls to be paired together should be as near alike as possible as regards depth of chill and hardness of face, as the expansion when they are heated will then be nearly the same and one roll will not have a tendency to rough up more than the other one.

If there is any difference in the rolls, the deeper chilled one should be selected for the concave roll for two reasons, first because the concaving will reduce the depth of chill at center of roll, and secondly, because the deeper chilled roll has the greater expansion, due to chilled portion of roll having more expansion than the grey iron comprising the interior of the roll, and when the concavity is all in one roll, this roll should be placed on the top because the top roll gets the hotter and as the bottom roll does the driving for both rolls on the finishing stands, the lighter chilled roll should be used on the bottom.

Same End of Roll to Drive.

Another good practice is to keep the same end of roll towards the drive each time in. The reason for this is that a torsional strain is set up in the rolls, due to the great power required to drive them while rolling sheets, which tends to a displacement of the crystals comprising the mass out of their original position and if the direction of this strain is continually reversed, it acts as a backward and forward bending strain would on a piece of sheet metal until it finally lets go.

An old and new roll should never be paired together if it is possible to avoid it, as their expansion is radically different.

Hardening Face of Rolls.

Whenever time will permit it is advisable, after topping the rolls, to let them run together for a while before removing them from the lathe as the weight of the top roll closes up the surface of the roll which

has become roughed up due to the tearing action of the turning tool. If this can be done, the rolls will hold a much better surface when the mill is first started up.

After the rolls have been fitted a light cut $2\frac{1}{2}$ inches wide should be taken off each end of the surface so that there will be no extreme narrow bearing on the ends of rolls before they are expanded by heating. This is especially true on tin mills where the bars are roughed down on the finishing rolls and the continual dropping of the top roll tends to spawl off the ends of the roll.

The amount of cross put in the rolls depends upon the diameter of the rolls, the width of sheets to be rolled and whether they are for sheet or tin plate, the depth of chill, and time they have been in service, and usually varies from two to three inches cross.

Dressing Rolls.

In dressing hot mill rolls, it is neither necessary nor desirable to remove all of the oxidized surface from the center of roll face, so long as the rolls are properly fitted. This is simply a waste of chilled face as the oxidized portion will give a better surface than it is possible to get after tearing it off with a tool.

Cold Rolls.

Cold rolls, as their name implies, are used for the cold rolling of the finished sheets and are both turned straight except that the ends of rolls are chamfered off to a width $3\frac{1}{2}$ inches in order that the excessive heavy pressure due to cold rolling will not spawl off the ends of the rolls. These rolls are also highly polished on their face with oil and emery to give the sheets a highly finished surface.

The sketch submitted herewith is of a straight edge holder found in use in one of the sheet mills and for which the writer claims no credit.

It is made from sheet steel with the edges bent up to stiffen it, is adjustable to any cross and a very efficient tool. In use it is laid flat on the piano rest of roll lathe.

Electricity in a Large Modern Steel Plant

An Analysis of the Application of Electricity Throughout the Entire Process of Iron and Steel Production—Details of Electrical Apparatus at the Maryland Plant of the Bethlehem Steel Company.

By R. B. GERHARDT.

PART I.

IT IS the object of this paper to follow through the various steps in the process of manufacture of steel products from raw material, in a modern steel plant, and to point out the part that electricity plays in each step. In order to do this in a more illuminating manner the writer has taken as a concrete ex-

ample, the Maryland plant of the Bethlehem Steel Corporation, which is now nearing completion, after undergoing an extensive construction program for the past four years, involving the expenditure of \$50,000,000.

At Sparrow's Point raw materials for making steel are received; iron ore by a line of the company's steamers from Bethlehem mines in Cuba and Chili; coal by rail or on scows from the mines in Pennsyl-

Paper read before Philadelphia section of the Association of Iron and Steel Electrical Engineers.

vania and West Virginia, and limestone by rail from the company's quarries in Maryland and Pennsylvania. The ore steamers mentioned were designed and built especially for carrying bulk cargoes, and are similar to lake type boats with machinery and boilers in the stern, and with large hatches, so that the whole cargo can be handled with ease by grab bucket unloaders. The principal dimensions of these boats are: capacity, 13,000 gross tons cargo; length, 468 ft.; beam, 57 feet; maximum speed, 10 knots; some are equipped with turbine drive and some with engine drive. They have six cargo hatches 33 ft. by 37 ft. There are no distinctive electrical features about these steamers. Each carries the ordinary lighting plant and wireless equipment with sending radius of 2,000 miles. These steamers, however, do not represent the last word on ocean type ore boats, as there are now under construction at the Sparrow's Point shipyard two 20,000-ton boats for the Chilian trade.

Ore Handling Plant.

The steamers are docked at the ore wharf, and unloaded with two 7½-ton Brown unloaders and two 15-ton Mead-Morrison unloading bridges. The former handle the ore into cars or into a trough from which it is put into stock piles in the ore yard, with a Hoover & Mason 15-ton ore bridge, while the latter can handle the ore direct from the boat into the stock pile. Until the present time, the second Mead-Morrison bridge has not been put into operation, but with the remaining equipment a cargo of 10,000 tons is unloaded in an average working time of 16 hours. The bridges cover a trestle which connects the blast furnace stock bins and carries electric scale type transfer cars, which weight and distribute ore and stone to the furnaces. The limestone comes to the plant by rail, and is unloaded from a trestle on the wharf side of the ore storage yard. All of the ore handling equipment is electrically-driven, requiring a total of 60 motors, representing 3618 hp. The electrical problems encountered in connection with this apparatus are principally the handling of the very heavy currents required and the working out of refinements in control. The average power required to handle a ton of ore from steamer to stock pile and from thence into the furnace stock bins is 1½ to 2 kw hours.

Coal Handling Plant.

Coal is received on large open scows and unloaded with two Mead-Morrison 7½-ton bridges, and handled either into the stock pile or into a weighing hopper and into cable cars, which deliver it onto inclined belts and into the bins over the breakers. When coal is received by rail it is dumped into one of four unloading pits, located on the opposite side of the yard from the wharf, and is then handled by the bridges. Plans are being made for later installing an electric car dumper, which will deliver coal into the cable cars and from these cars it can go either to the belts or can be distributed in the yard and put into storage by the bridges. After the coal passes through the breakers, of which there are two, driven by 75 hp in-

duction motors, it goes up a second inclined conveyor to a bin over the crushers, the waste from the breakers going to various parts of the plant where it can be made use of. There are four Pennsylvania Crusher Company's crushers, each driven by a 400 hp, 750 rpm slip ring induction motor, and the coal after passing through these is carried up a third inclined belt conveyor, and over a system of conveyors into one of three bins, which feed the six batteries of by-product coke ovens. All of the coal conveyors, feeders, etc., are built in duplicate, so as to insure continuous operation. The electrical equipment for the coal unloading and crushing plant consists of 56 motors, representing a total load of 4101 hp. The bridges are operated on a 250-volt, d. c. circuit, and all remaining apparatus on a 550-volt, 3-phase, 25-cycle circuit. One of the features of the control of the coal handling equipment is the interlocking scheme, by means of which the operators, in the event of something going wrong, with any piece of apparatus in a unit conveying system, can readily shut down the system, thus preventing any piling up or spilling of the coal due to such failure. This scheme is the result of considerable experience with such interlocking schemes at Sparrow's Point.

All stationary motors in dusty and dirty locations are mine-type machines, totally enclosed and arranged for suitable ventilation. This also holds true of the motors on the coke handling system, where the dust and dirt has even a more disastrous effect on insulation. All open-type motors, such as the large crusher motors, are located in a dust-tight room, with ample ventilation. No motors are installed on a gear drive without interposing a flexible coupling between motor and pinion shaft.

Coke Ovens.

There are six batteries, 60 ovens each, of Koppers by-product coke ovens, each of which have a coking capacity of 750 tons of coke per 24 hours. The crushed coal from the three bins before mentioned, is distributed to the individual ovens by means of electric larry cars, which travel over the top of the ovens on a track provided for this purpose, and which carry just sufficient coal to make one oven charge. This charge is weighed into the larry from the coal bin. To charge an oven, doors in the roof of the oven are removed, the larry car spotted over these openings and slowly dumped. When the oven is nearly full of coal the levelling ram on the pusher is run back and forth through a side door near the top of the oven which uniformly levels off the charge. The oven doors are then sealed up and the coking process takes place. Gas and tar pass off into a large collecting main running the length of the battery and connected to each oven. From this main the gas is exhausted by means of turbine-driven centrifugal exhausters into the by-product plant, where the various by-products are extracted, and it is then pumped to the city of Baltimore for domestic uses. The turbines above mentioned, together with a small steam-driven air compressor, represent the only drives which are not electric in this coke oven plant. The benzol plant, however, which is isolated from the remainder of the

plant, contains all steam-driven auxiliaries on account of the highly explosive and inflammable nature of the product handled. The lighting around this plant has to be closely watched, as nothing but sealed work and vapor-proof fittings are allowed. The steam used at the coke ovens for the exhausters, pumps, stills, etc., is produced in a modern boiler plant, equipped for burning coke breeze. The electrical equipment for the by-product end of the plant, including this boiler house, consists of two grab bucket cranes, one for handling sulphate and one for handling coke breeze, and nine motors driving centrifugal pumps, representing a total of 1215 hp. Quite an item of electric power is represented in a fresh water pumping plant, which is equipped with eight Ingersoll-Rand Imperial type 10-B, 16"x10"x14" air compressors, driven by 100 hp motors for blowing the wells and four centrifugal pumps, two driven by 100 hp motors, and two by 150 hp motors for handling the water. In the gas booster pumping station for pumping gas to Baltimore and to the sheet and tin mills, there is one 25 hp two-speed induction motor-driven reciprocating pump, two 200 hp single speed induction motor-driven reciprocating pumps, two 200 hp two-speed induction motor-driven reciprocating pumps, all of these being belt-driven, and two 600 hp 6600-volt synchronous motor-driven direct connected reciprocating pumps.

After the coking process has taken place the gas connection is closed off, the oven doors are removed on each end of the oven by electric door machines, specially designed for this purpose, a guide placed on the discharge side, and the coke car (handled by electric locomotive) is placed to receive the coke. Next the electric pusher ram is run through the oven pushing the hot coke out into the car, from which it is dumped, after quenching, on to a wharf, and allowed to cool. From the wharves the coke is fed on inclined belt conveyors and carried to screening stations where the fines are removed, and it then passes over belts to stock bins over the blast furnace trestle to be handled from this point into the electric scale transfer cars and into the furnace stock bins.

The heating of the ovens is accomplished by means of gas, and this is burned on a regenerative principal. Reversing the burning of this gas is taken care of entirely automatically by means of master clocks and electric reversing mechanisms for each battery. To maintain the gas pressure as nearly constant as possible in the gas and tar collecting main on each battery, an electric governor is used consisting essentially of a motor operated butterfly valve which is opened or closed as the pressure rises or falls, the motor being controlled by a pontoon switch.

There are two electric door machines and one pusher for each of the six batteries, while one 20-ton locomotive serves two batteries for handling the coke. The method of getting current to these machines is quite an electrical problem, which we think has been mastered after years of experience. The door machines and pushers are fed in battery units through a set of conductor angles, located above the oven doors along each side of the battery, and the insulating of

these angles is the big problem, as such insulation has to stand ice, moisture, dirt and heat from the coke, as well as strains from expansion of the bars. Asbestos-covered wood blocks covered by a sheet iron trough have served the purpose fairly well, but the best insulator is a trolley barn hanger, using porcelain instead of moulded composition as an insulator with outer canopy for protection. For feeding the electric locomotives a catenary trolley design is used with pantagraph collector on the cars. A one-in. galvanized steel cable is stretched the length of the battery, one over each track, and from this is suspended a $2\frac{1}{2}" \times 2\frac{1}{2}" \times \frac{3}{8}"$ —5.6 pound T. bar trolley by means of 5-16 galvanized steel wire drops every 10 feet. The whole catenary is insulated, and in addition each drop carries a porcelain insulator which is not affected by the weather or temperature.

For the total coke oven plant, including the coal unloading and crushing end, and by-product plant, there are a total of 174 motors representing 8035 hp. The power consumption of these motors per ton of coke averages 1.3 kw hours per ton.

The lighting of the coke oven batteries is accomplished mostly with flood light projectors, which method is very effective since these units can be placed out of range of the heat, smoke and dirt and still be very effective.

Blast Furnaces.

There are four 450-ton blast furnaces in operation, and two 500-ton furnaces nearing completion. All of these are built essentially alike as far as the stocking, charging, blowing and tapping features of design are concerned.

The stock bins are of reinforced concrete with cast wear plates in the bottom. The stock is handled by Hoover-Mason electric scale transfer cars into these bins, and fed from the bins over the roller feeders into cylindrical buckets with bell hopper bottoms.

The buckets with contents are weighed and handled to the skips by Hoover-Mason electric scale larry cars, each car carrying two buckets and provided with a motor for rotating same, while being filled to give an even distribution of the stock going into the furnace. The skips pick the buckets from the larrys and carry them up to the top of the furnace and dump them. While one bucket is traveling up the skip and being dumped, the other is carried by the larry under the bins for filling. The four older furnaces are equipped with Otis two-speed ac induction motor-driven skips.

For blowing the furnaces there are two gas-blowing engine stations, arranged for a total of 14 Bethlehem 47"x60" gas end, 84"x60" air end engines, and all necessary auxiliaries, including gas washers, pumps and compressors, and these two stations operate in conjunction with the old steam-driven blower station, which contains four Corliss engines 42"x81"x60" steam end, 84"x84" air end, and two older engines 38"x38"x60" steam end, and 84"x84" air end. Some of the steam blowers are arranged for blowing Bessemer

converters. A condenser plant also forms part of the steam station. There are four stoves or hot ovens for each blast furnace as well as dust catchers, separators and a static washer for rough cleaning of the gas.

Each of the four older furnace layouts comprise a battery of gas fired water tube boilers, 10 per furnace, making a total boiler plant of 10,000 bhp. The most of these boilers are not operated unless there is a surplus of gas from the gas engines. There are two fresh water pumping stations arranged so that each takes care of a battery of four blast furnaces, and equipped with motor-driven compressors and pumps.

Included in the blast furnace department in addition to the blowing engine houses is a ladle house, pig casting plant, skull cracker plant and sintering plant, and all of the equipment in these plants is electrically-driven. For the total department there are six larry cars, seven cranes and 42 additional motors, totaling 7854 hp, not including furnaces Nos. 5 and 6, which have 54 motors, representing 3033 hp. The average power consumption per ton of pig iron excluding casting plant and sintering plant is 6.9 kw hours. The casting plant runs only intermittently, as hot pig iron from the furnaces is shipped in ladles direct to the open hearth plant, and consequently is not figured in this power.

The power consumption of the sintering plant averages 15.5 kw hours per ton of sinter.

Open Hearth.

There are two open hearth plants. No. 1 contains five 50-ton tilting furnaces which are operated as straight, basic steel producing units, or in conjunction with the old No. 1 Bessemer plant, equipped with metal mixer, iron cupolas and four 18-ton converters, to produce duplex steel.

The electrical equipment represented in No. 1 Bessemer and open hearth plants consists of seven 75-ton ladle cranes, one floor type charger, one stock yard crane, one gas house crane, two heavy broad gauge trolley type motor cars, and three narrow gauge trolley type motor cars. There are 96 motors, totaling 4711 hp.

No. 2 open hearth plant is built as a duplexing unit and contains one 1,300-ton hot metal mixer, which receives the hot pig iron from the blast furnaces. Metal from this mixer is drawn off into a ladle and poured into one of three 25-ton Bessemer converters, where it is blown, and then removed in a ladle and charged into one of four 200-ton tilting furnaces to undergo the open hearth process. Provisions are made for a second 1,300-ton mixer and a fourth converter when it is desired to increase the capacity of this plant. A 250-ton hot metal mixer is installed between No. 2 and No. 3 open hearth furnaces to hold hot pig iron for making up the open hearth heats. Steel is drawn from the furnaces into 100-ton capacity ladles and poured into moulds from the various pouring stages in the pit. The furnaces are arranged to burn oil, tar or producer gas. A gas producer plant is located adjacent to the furnace section of the duplexing plant and is equipped with electric-driven ma-

chinery for handling coal and ashes. A waste heat boiler, rated at 600 bhp., is installed in connection with each furnace. Steam from these boilers is used at the gas producers and in the finishing mills.

A liberally designed bottom house forms a part of the Bessemer plant, and is equipped with electric crane, grab bucket trolley and motor-driven grinding and crushing machinery, and gas-fired drying ovens.

The crane equipment in No. 2 open hearth consists of two 175-ton ladle cranes, with 40 and 15-ton auxiliary hoists for handling open hearth heats, and one 100-ton ladle crane with 25 and 10-ton auxiliaries for pouring iron into the mixer, all located on the pit side runway. Also on this runway in between the ladle cranes are provided two high speed cranes with 40 and 10-ton hoists for handling pit clean-up, moulds and general light work. On the floor side runway there are three 100-ton ladle cranes with 25 and 10-ton auxiliaries, one for handling iron from the mixer to the converters, and two for handling steel from converters to the furnaces and for general work. There are two floor type charging machines, two 15-ton stock yard cranes, one 15-ton mould yard crane, one 10-ton auxiliary bottom house crane, two gas house grab bucket cranes, one bottom house grab bucket trolley, one Shepard monorail trolley for handling ashes, and three ladle crane repair trolleys.

The following table gives the electrical equipment for the principal units in this plant:

Duplex Open Hearth Electrical Equipment, Per Unit.

		Motor Per Unit	H.P. Rating	Control	Brake
175 T. Ladle Crane	Main Hoist	2	150	Magnetic	Yes
	1st Aux. Hst.	1	75	Magnetic	Yes
	2nd Aux. Hst.	1	55	Magnetic	Yes
	Main Trolley	1	37.5	Manual	No
	Aux. Trolley	1	15	Manual	No
	Bridge	2	75	Magnetic	No
100 T. Ladle Crane	Main Hoist	2	100	Magnetic	Yes
	1st Aux. Hst.	1	75	Magnetic	Yes
	2nd Aux. Hst.	1	37.5	Manual	Yes
	Main Trolley	1	37.5	Manual	No
	Aux. Trolley	1	15	Manual	No
	Bridge	2	75	Magnetic	No
1,300 T. Hot Metal Mixer	Tilting	2	75	Magnetic	No
	Door Raising	1	7.5	Manual	Yes
25 T. Bessemer Converter	Tilting	2	100	Magnetic	Yes
	Air Gate Valve	1	3¼	Manual	Yes
	Air Butterfly	1	3¼	Magnetic	No
200 T. Open Hearth Tilting Furnace	Tilting	4	75	Magnetic	No
	Door Raising	6	4	Manual	Yes
	Gas Valves	2	37.5	Magnetic	No
Gas Producers	Rotate Y	1	5	Manual	No
Coal Handling	Hoist	1	30	Magnetic	Yes
	Larry Car	1	15	Manual	Yes
Scrap Handling	Hoist	1	150	Magnetic	Yes
	Larry Car	1	37.5	Manual	Yes
250 T. Mixer	Tilting	1	55	Manual	No
	Door Raising	1	7½	Manual	Yes
Waste Heat Boilers	Blowers	1	75	Manual	No
Bottom House	Grinding Panis	1	75	Manual	No
	Crusher	1	75	Manual	No
	Haulage Winch	1	30	Manual	Yes

The remainder of the plant will be dealt with in future installments.

Important Factors to be Considered in Heating and Cooling Steel

Uniform Pyrometer Record Not Sufficient Indication of Proper Heating or Cooling—Temperature, Time, Surface and Mass Are the Factors Which Must Be Considered in Heat-Treating.

By C. B. BARNHARDT,
W. S. Rockwell Company.

IT IS generally assumed that the proper heat-treatment of large quantities of steel of similar size and shape requires nothing more than a uniformly heated product; that a uniformly heated product requires nothing more than a uniformly heated furnace; that a uniform pyrometer record indicates a uniformly heated furnace and, therefore, a uniformly heated product within that furnace. Nevertheless, variations in metallurgical quality of the finished product frequently occur even with an indicated uniform temperature in the furnace chamber. There is a great deal more in the problem than the maintenance of a uniform temperature in the heating chamber. It may be expected that there would be a material variation in the uniformity of heated product from furnaces of different types, but, as a matter of fact, wide variations quite frequently occur in material heated in the same type of furnace, the pyrometer readings in each case being the same. Such variations are generally brought about by a difference in method of placing material in the chamber and of applying heat to the material so placed. The final test is the uniformity of the heated product, which is determined by the manner in which the individual piece is cooled. The cooling is of great importance, although as a rule little attention is paid to this portion of the process.

While uniform heating is one of the main factors in the heat-treatment of metals, it is the uniformity of the final set or adjustment of the structure in cooling that determines the uniformity of the actual heat-treatment.

To heat the charge uniformly it is necessary that each piece be subjected to the heat in the same manner, at the same temperature, and for the same length of time. This requires something more than a furnace which will maintain a uniform temperature, without reference to the manner in which the heat at that temperature is applied to the material in the furnace.

If a large quantity of material is piled in a chamber, it is very likely that the outside pieces will be heated to, and cooled from, a higher temperature than the pieces at the center or at the bottom of the mass. If a large quantity of uniformly heated pieces is plunged into a quenching bath at one time, there is a tendency for the bath to become irregularly heated and for the pieces at the outside of the mass to cool

at a different temperature and in a different period of time than those in the center.

With such mass methods of heating and cooling it is unreasonable to suppose that each piece receives the same amount of heat or is subjected to the same heat-treatment. Notwithstanding the temperature indication, unless all pieces are heated and cooled exactly alike, the indication of uniform temperature, either in the heating or cooling zone, serves merely as evidence but cannot be accepted as proof of a uniformly heated chamber, a uniformly heat-treated product within that chamber, or a uniformly heat-treated product as the final result. There should be a better appreciation of the difference between a pyrometer record indicating an apparent uniformity of temperature in a chamber and of the factors that determine the uniform heating of a piece to that indicated temperature.

A piece of fairly low grade steel, by proper and careful heat-treatment, may be made to meet physical requirements that a higher grade steel, improperly or carelessly heat-treated, would not meet. Of course, no heat-treatment, however good, will ever make the low grade steel as good as the high grade steel can be made.

Doctor Howe, in his book "Iron, Steel and Other Alloys," page 241, states: "You cannot make a bad beefsteak good by the cooking; you can cook it better or worse, and it will be a worse or a less bad beefsteak, but always bad. On the other hand you can easily spoil a good beefsteak by bad cooking. Now, just as cooking is to food so is heat-treatment to steel. Indeed, a pedantic cook might reasonably call cooking heat-treatment."

Doctor Howe's homely simile is very apt and to the point, and it would seem in order to draw a few comparisons between the stove that cooks the steak and the average furnace that heats the steel.

The housewife, unconsciously perhaps, shows an appreciation of the fundamentals of good heating when she uses a slow fire in baking bread or in cooking a pudding, of which the center has to be thoroughly done. She cooks a 10-pound roast much longer than a three-pound roast. She realizes that if she fills her oven completely with food, it will prevent the proper circulation of heat. She does not take it for granted, just because the thermometer on the oven door registers a given degree of heat, that her bread or pudding is well done. She makes certain that these

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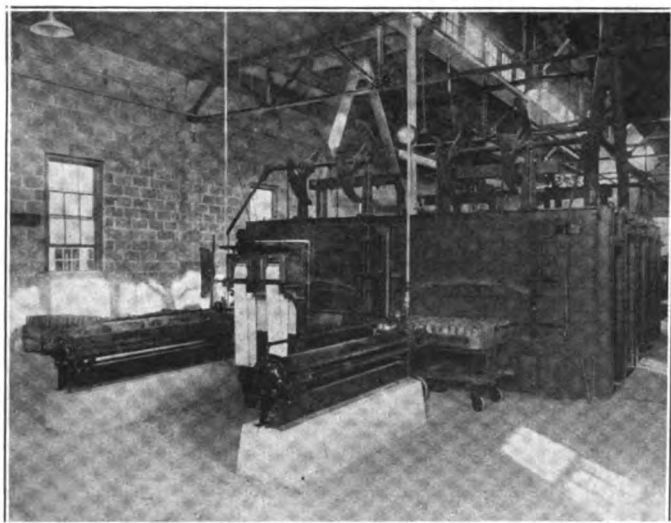


Fig. 1—Semi-Automatic twin-chamber heat-treating furnace. The heating chambers of the furnace have door openings at each end. The material to be heat-treated or annealed is charged in pans, the pans being pushed through the furnace with pneumatic pushers.

are so placed in the oven that the indicated heat is applied uniformly to the bread or pudding.

While the application of heat in a furnace is better than in a cook stove, it is questionable whether the average heat-treater manipulates his dampers as intelligently as the housewife does, or employs the same effort and skill to get a properly heat-treated product.

Many furnaces now in use are not provided with the dampers so essential for controlling the air entering and the gases leaving the furnace. Even when furnaces are frequently pulled wide open and left so, or sometimes entirely closed, the spent gases being permitted to escape from the heating chamber as best they can, often completely destroy the effect of good heat distribution within the chamber.

Consideration of uniformly heat-treated product involves four factors which govern the heating and cooling of all material, whether it be a loaf of bread or an ingot of steel, i. e.: Temperature, Time, Surface and Mass.

1. **Temperature:** The degree of heat required in the product to produce a given molecular formation and grain structure. This is more generally appreciated than the other three factors involved.

2. **Time:** The period required to saturate the individual piece to the required temperature and to per-

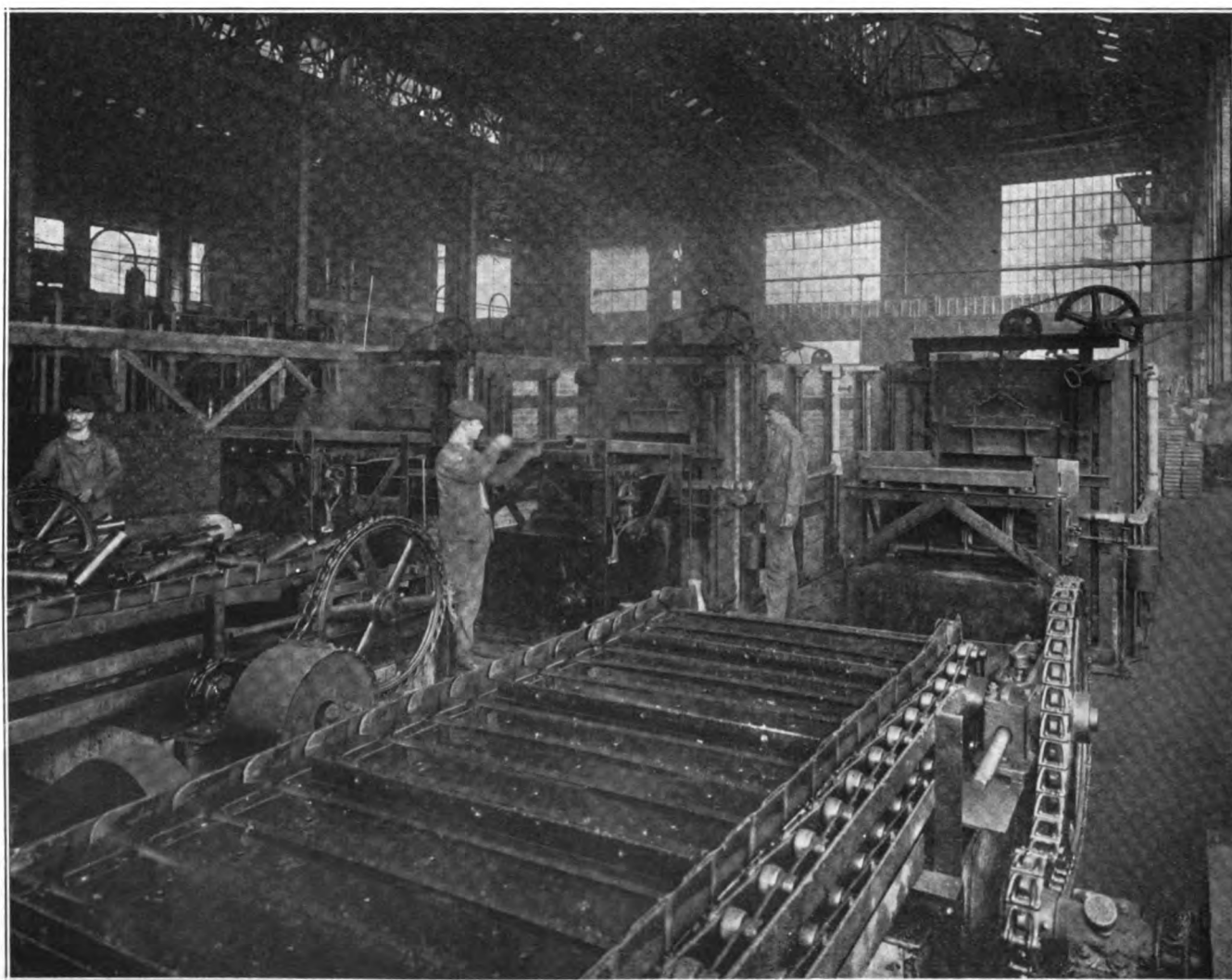


Fig. 2—A continuous automatic furnace installation. The charging ends of the tempering furnace units are shown. In the immediate foreground are the quenching tanks at hardening furnaces.

mit the required metallurgical reaction or diffusion and equalization.

3. **Surface:** The area of the individual piece exposed to the heat—which influences the rate of heat absorption, the time of saturation and the degree of uniformity throughout the piece.

4. **Mass:** The unit body to be heated—which influences the time required for saturation, the rate of absorption and the manner of exposure to the heat. Mass should be considered with reference to the individual piece and with reference to a mass composed of a number of individual pieces.

Temperature and Time are the two basic factors. The temperature is determined by the metallurgical requirements. The time period is based primarily on the factors of surface and mass, which may be laid down as a rule to govern the heating or cooling operations. Due regard must be paid to the nature of the material itself. For instance, the time required for the proper saturation of a low carbon steel might vary from the time required for a high-grade alloy steel of identical surface and mass. Generally, in annealing, the time allowed for heating or cooling is too short, particularly with large pieces. From the heat-

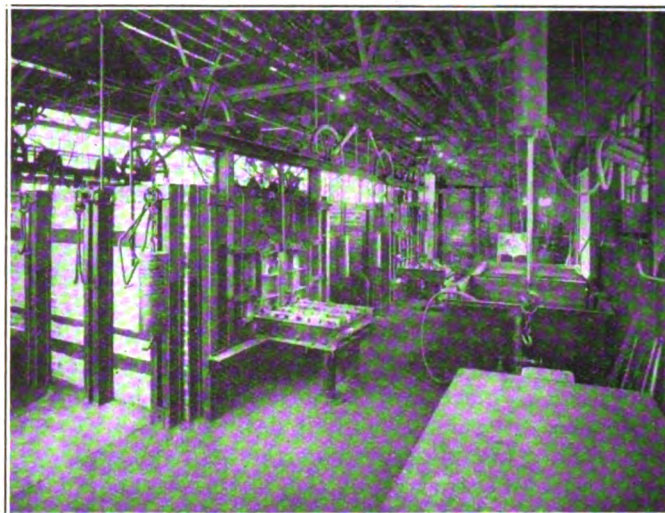


Fig. 3—Semi-automatic die heating furnaces—Car and ball type—Discharging ends. Dies are supported on carriages and pushed through the heating chambers on balls rolling in ball tracks. Pneumatic pushers are provided.

ing standpoint this statement also holds good in some

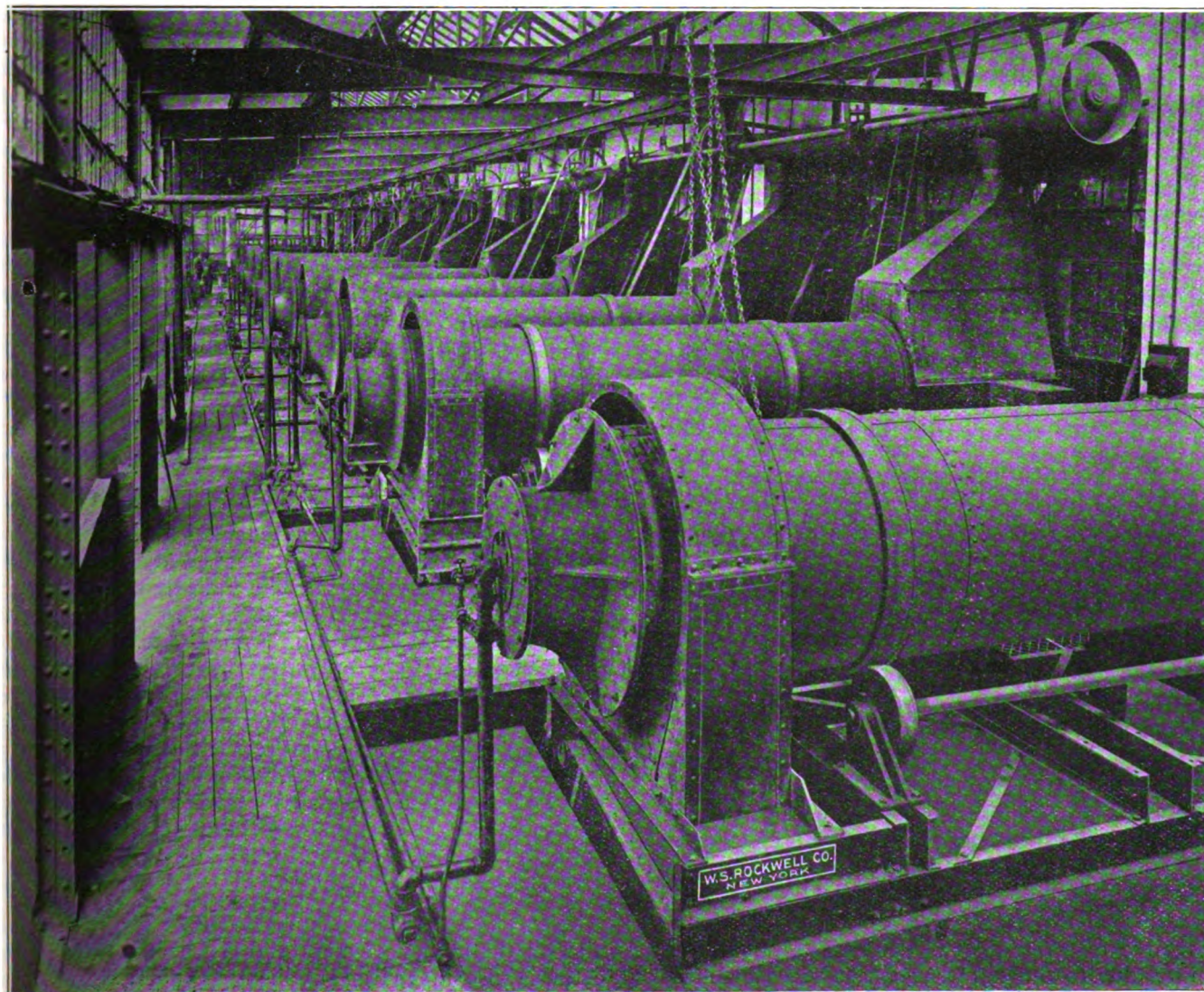


Fig. 4—Rotary automatic heat-treating furnaces—Discharging ends. Furnaces are used for the heat-treating of small forgings and the annealing of small pressed steel parts.

cases where there are large surfaces in proportion to mass, as in the heating of large circular saws for hardening.

It is desirable to expose to the heat as much of the surface of the individual piece as possible. This holds good whether the operation is one of heating a single piece as a mass or of heating a quantity of individual pieces as a mass. This done, the only other element seriously affecting time is the mass, whether it is the mass of the individual piece or the mass of a quantity of pieces. When heating or cooling a quantity of individual pieces at the same time, it is desirable to avoid the large mass effect in order that there shall be no material variation in the surface area of each individual piece exposed to the heating or cooling atmosphere. In such cases it is desirable to break up the mass in a manner to reduce the depth of material and increase the surface of the material exposed to the heat. This generally reduces the time required and results in more nearly exposing each piece to the same temperature for the same time, instead of subjecting the outside of a dense mass to the heat for a longer time than the pieces at the bottom of the mass.

The ideal cooling condition is approached when these same factors are considered after heating. An illustration of this, from the standpoint of heating, would be to consider the difference in uniformity of a product in the form of small balls or bolts piled in a large mass on the hearth of a stationary furnace, or when passed through an automatic furnace in the form of a thin stream or layer. In cooling there would be a pronounced difference in uniformity resulting from plunging such a mass of heated material into a non-circulating bath and dropping a few pieces at a time into a circulating bath.

The construction and operation of the automobile radiator illustrates the relationship of mass and surface to time and of time to temperature. In the radiator it is necessary to break up the mass and to increase the surface in order to decrease the time of cooling. The same laws control the heating and cooling of steel.

In heating large dies it is desirable that they be thoroughly saturated at a temperature slightly below the final temperature before the formed corners or edges on the face reach the final temperature. As the life of a die is no greater than the life of the corners or edges, it naturally follows that every possible effort should be made to prevent overheating the corners or exposing them to the final temperature any longer than is absolutely necessary. The corners of the piece are the first to heat up and the first to cool off, and it is at these same sections that the evil effects of unequal contraction are manifested. These corners heat and cool more rapidly because the surface in proportion to the mass of these sections is much greater than that of the body of the die, which naturally reflects a difference in time of heating or cooling. With such dies it is most essential to consider the difference in time required to reach a given temperature in heating or cooling, due to the difference in surface and mass of the various sections of the die. Improper heating and cooling, resulting from a disregard of these fac-

tors, are responsible for a great deal of the limited service and loss of production, material and labor. Such loss greatly offsets any saving in time or fuel resulting from an attempt to heat the piece quickly without due regard to all the factors involved.

The difference between a small piece and a large one is mainly one of degree, insofar as these points are concerned. The principles hold good in either case. When a quantity of small pieces is heated indifferently, those on the outside of the charge are likely to be affected as the corners of the die, and while, in one case, it is only those outside pieces that are spoiled, in the case of the die the entire piece is ruined. The heat-treatment of a small piece involves no large amount of money and the difference in cost between proper and improper methods is surprisingly slight. The difference in results is all out of proportion to the cost, and it is only good business to bear the slight extra cost in order to produce a superior product, which is cheapest in the long run. In many cases a piece may be properly heat-treated by a suitable method much more cheaply than by an inferior method.

The usual lack of consideration of these points of identical area and time of exposure for saturation accounts for the variations that so often occur in the finished product without any apparent change in the indicated temperature. Notwithstanding how elaborate the pyrometer or temperature recording system may be, good results cannot be secured unless the factors of mass and surface are considered along with the temperature and the time.

The practice of charging and discharging material to or from a furnace without regard to these factors, but with an eye only to the pyrometer, seems to be more of a job of manufacturing pyrometer records than of producing a uniformly heated product. The manner of exposing a piece to the heat is just as important as the manner of indicating the temperature of the heat to which it is exposed. The pyrometer does not necessarily indicate the temperature of the material but merely the temperature of that part of the chamber in which the couple is located. Like the gauge on the steam line, it indicates the existence of heat energy but it does not necessarily indicate the use made of that energy. The indicated temperature must be considered with the element of time and with the influence that the factors of mass and surface have upon the time. The only test worth while to determine these points is the degree of structural uniformity disclosed by the microscope. A laboratory determination of temperature, with a surface exposure or mass effect different from that likely to obtain in the shop, is frequently responsible for material variations in quality disclosed by physical tests, in spite of evidence in the form of pyrometer records to show they should not exist.

Proper consideration must be given to the importance of the human element and the necessity for educating those in charge of heating operations upon whose skill and judgment depend many subsequent operations and a considerable amount of money.



The Performance of Mechanical Stokers

Results of Eighty Tests Which Were Made on Typical English Boiler Plants—Conclusions on Efficiency, Life of Boiler, Steam Produced and Other Power Plant Factors.

By DAVID BROWNLIE.

THE following paper was read by the author before the Institution of Mechanical Engineers of England, and is abstracted in the following pages from London "Engineering."

The Performance of Mechanical Stokers.

In this paper it is proposed to deal with mechanical firing, and the exact figures obtained by the complete scientific investigation of the working of 80 typical "Lancashire" boiler plants, mechanically fired, will be brought forward for consideration. The firm with whom the author is associated have been engaged for the past 10 years in testing and reorganizing steam boiler plants, and the figures in this paper have been obtained during the course of this work.

Exact figures for the performance of 80 typical plants were given in the original paper. These 80 typical plants are not selected cases, either good or bad, but are plants taken at random, according as his firm was instructed to undertake the work by the various owners of the plants. In the author's opinion, although he can give no actual evidence to support it, these 80 plants are typical of the mechanically-fired "Lancashire" boiler plants of the whole country of England. He found by experience that it is not generally the firm with the most wasteful plant that is more interested in modern methods of coal economy. Rather it is the firm whose plant is

average, or above the average, which is more interested in all possible saving to be obtained, and he feels sure that if a number of hundreds of mechanically-fired "Lancashire" boiler plants were investigated on the lines described, that the results would on the average not be very different. He is more convinced of this because his firm has examined, without testing, hun-

dreds of mechanically-fired boiler plants, and found them to be all run on the same general lines as the 80 plants.

Before considering the results, he would like to add that on each of the plants a most complete scientific investigation was carried out, not only for one working day, but also for one week, as a check test. The object of the test was to find out the exact normal every day working conditions of the plant, particularly as regards efficiency, so that a scheme of reorganization could be devised for the more economical production of steam. In every case the boiler-house staff worked the

This article on the "Performance of Mechanical Stokers," was written by an English engineer and is published in these columns mainly for the purpose of showing the great variation between power plant practices in America and in England. The English have not, to date, employed to any extent the large boiler units which are commonly used in this country. The author's conclusions regarding the value of mechanical stokers are certainly very interesting. No doubt, a great majority of American power plant engineers will disagree with many of the author's conclusions. The Blast Furnace and Steel Plant will welcome any opinions or discussions of this paper and will be glad to publish them in this department in following issues.

plant as usual, and at the end of the tests the water level in the boilers and the general conditions of the fires was the same as at the commencement.

As regards the size of the plants, these are quite representative, varying from the largest plant of 16 boilers, with an annual coal bill of 79,000 tons, down to plants of one boiler, with the smallest annual coal bill of 950 tons. The total annual coal consumption

on the whole 80 plants is approximately 715,000 tons, and the total number of boilers 299. The number of different makes of mechanical stoker included in the tests is eight, three being sprinkling and five coking.

Out of the 80 plants, 17 are fully equipped with super-heaters, 18 are partially equipped, and 45 (56.26 per cent) have no super-heaters at all.

Analysis of Advantages and Disadvantages.

Efficiency—It is claimed that mechanical firing is more efficient than hand firing, and most extraordinary statements on this point are made by some firms supplying mechanical stokers. One firm states that the average saving is 10–40 per cent of the coal bill, and instances are given of even 52.5 per cent saving. Another firm states that on an average the saving obtained in two years will pay for the cost of installation. Most mechanical stoker firms claim that mechanical stoking is bound to be more efficient than hand firing, because it is not necessary to open the doors to clean out. The details of tests generally given in makers' catalogues are equally extraordinary. Many of the results of these tests are very difficult to follow, and it is often not clear whether they apply to the boiler only or to economizers and super-heaters as well. However, some specimen results are 78.43 per cent efficiency on "Lancashire" boilers and economizers, and 70.02 per cent, 72.58 per cent, 76.62 per cent, and 81.1 per cent on "Lancashire" boilers only, and so on. These statements give the impression that such results are a matter of course—if mechanical firing is adopted.

The average net working efficiency for the 80 plants, including economizers and super-heaters, after deducting the steam or power used to produce steam, is approximately 59.0 per cent. For the boilers only the figure is approximately 53.0 per cent. The corresponding figure for the 250 plants (76 per cent hand firing and 24 per cent mechanical firing), is 60.09 per cent, and the figures can be summarized as in Table 1:

Table 1.

	80 Plants Mechanically Fired		250 Plants (76 per cent Hand-Fired and 24 per cent Mechan. Fired)	
	No. of Plants	Per Cent	No. of Plants	Per Cent
Over 80 per cent	1	1.25	2	0.8
75 per cent to 80 per cent....	2	2.50	9	3.6
70 per cent to 75 per cent....	2	2.50	13	5.2
65 per cent to 70 per cent....	17	21.25	30	12.0
60 per cent to 65 per cent....	11	13.75	44	17.6
55 per cent to 60 per cent....	16	20.00	62	24.8
50 per cent to 55 per cent....	15	18.75	47	18.8
Less than 50 per cent	16	20.00	43	17.2
	80	100.00	250	100.0

As already stated, it must be remembered that the 80 plants are obtaining assistance above the average from economizers and super-heaters, and if the hand-fired plants were equipped to the same extent, the figure of 60.09 per cent efficiency would be about 61.5

per cent. The approximate figures which the author has for about 350 hand-fired "Lancashire" boiler plants show an average net working efficiency of about 62 per cent. These results show, therefore, that mechanically-fired plants as at present worked are actually obtaining worse results than hand firing.

In the 250 tests, 190 plants with hand firing were giving 57.8 per cent efficiency, as compared with 60 plants mechanically fired with 61.4 per cent efficiency. but the latter included some chain-grate stokers on tubular boilers. It will probably not be very far wrong to assume that there is little or no difference between mechanical and hand firing with the present methods of running boiler plants, and in both cases the average net working efficiency, including economizers and super-heaters and deducting the steam or power used auxiliary to the production of steam, is only about 60 per cent. The general idea that mechanical stoking on "Lancashire" boilers throughout the country is giving higher efficiency, as compared with hand-firing, is a complete fallacy, and after reading the extraordinary results given in makers' catalogues, it is somewhat of a shock to arrive at an average net working efficiency of, say, 59 per cent. In actual practice mechanical stoking is giving all kinds of results, from 40–80 per cent efficiency, and typical hand-fired plants will show about the same variation.

The question of the quality of the coal used is of the greatest importance in considering the performance of mechanical stokers. Many of the results given in mechanical stoker makers' catalogues are admittedly obtained with very very high quality coal, and with coal of this nature it is almost as easy to get good results with hand firing. If boiler plants were run on correct scientific lines, it is very difficult to say what the comparative results would be. If the coal is of good quality mechanical firing would probably give a slight advantage; with medium quality coal there would be no difference, and with poor quality coal hand firing would have a slight advantage. Under modern conditions hand firing would be, of course, considerably improved, and average results of 75 per cent efficiency would be obtained, so that the advantages of mechanical firing in this respect can be regarded as nil.

Table 2.

	80 Plants Mechanically Fired		250 Plants. Typical of the Whole County (76% Hand-Fired and 24% Mechanical Fired)	
	No. of Plants	Near- est %	No. of Plants	Near- est %
1. Very good over 12 per cent	3	4.0	4	1.6
2. Good, 10 per cent to 12 per cent	12	15.0	17	6.8
3. Medium, 8 per cent to 10 per cent	24	30.0	64	25.6
4. Poor, 5 per cent to 8 per cent	35	45.0	144	57.6
5. Very bad under 5 per cent	5	6.0	21	8.4
Total	79*	100.0	250	100.0

*One plant CO₂ not determined.

Percentage of CO₂—Following from paragraph 1, it is claimed that mechanical stokers give a higher percentage of CO₂ in the flue gases, and that less air is required per pound of fuel for combustion. For the 80 plants the approximate average figure for CO₂ is 8.25 per cent, and the figures can be summarized as shown in Table 2.

The average figure for the 250 plants as in Table 2 was about 7.1 per cent, and for 350 cases of hand firing only about 7.5 per cent. According to these figures, therefore, mechanical firing is giving very slightly better results than hand firing, but in both cases the general results throughout the country are poor, and could be greatly improved. If modern scientific methods were adopted, the author thinks that mechanical firing would give slightly better results, but the difference is not great. It is certainly not at all correct to claim any great advantage for mechanical firing in this respect. It is obviously an advantage in mechanical firing that the fire-doors need never be opened to fire the coal and to clean out. This advantage is, however, largely counterbalanced by the fact that on boiler plants, as generally worked today, mechanical fires tend to get thin at the back, and excess air is admitted at this point. The net result is a slight advantage only for mechanical firing, as shown by the CO₂.

Flexibility of Steam Output—Opinion on this point is very divided. It is stated as one of the advantages of mechanical firing that the boilers will respond to fluctuating demands for steam better than hand firing. On the other hand it is maintained by many steam users that mechanical stokers cannot respond as well as hand firing, and that they are, therefore, in this respect better adapted for steady loads only, such as cotton mills, flour mills, etc. It is not easy to decide this point unless most careful observations are taken, and the exact evaporation noted every half hour. The authors firm have done this many times, and their experience has almost invariably been that with boiler plants as generally run today, this is a defect of mechanical firing. Ordinary medium quality hand firing will respond to violent fluctuations in demand for steam in a way that is not possible with mechanical firing, whilst with good hand firing there is hardly any comparison. If boiler plants were run on correct scientific lines the advantage would still be with hand firing.

The results of the 80 tests can be summarized as follows:

Sprinkling Stokers: Type A—The steam jet apparatus consists essentially of a varying number of jets, 20 to 37, of approximately 3-32 in. to 1/8 in. holes on 1/2 in. steam pipe per furnace (that is, 40 to 74 per "Lancashire" boiler). Jets situated under the back of the furnaces on full boiler pressure and steam supply regulated with a hand valve, which is generally very little open.

The average steam consumption on 26 plants fitted with this type of stoker is about 5 per cent of the production, divided as follows in Table 3.

Type B—The steam jet apparatus consists essentially of six to eight jets, of approximately 1-16 in. to 1/8 in. holes on 3/4 in. steam pipe per furnace (that is, 12 to 16 jets per boiler on "Lancashire" boilers). The

Table 3.				
Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
22	3	5,057	101	0.50
42	2	4,735	110	2.10
2	2	9,190	159	2.10
38	2	7,062	110	2.50
73	2	3,016	74	2.60
54	2	3,073	112	2.70
21	3	8,193	159	2.75
69	3	3,257	101	2.75
35	1	8,734	103	3.00
47	1	7,457	100	3.20
1	2	11,146	157	3.25
17	2	4,305	122	3.40
20	4	5,316	96	3.50
60	3	3,182	74	3.50
66	3	2,555	75	3.50
75	7	4,907	62	3.60
18	3	5,833	110	3.75
28	6	5,366	86	3.80
58	2	5,789	104	4.12
4	4	7,350	78	4.90
39	2	3,368	141	5.30
8	2	6,714	153	6.50
32	4	6,769	110	7.30
14	1	3,929	85	9.40
48	3	4,311	77	13.50
79	7	4,343	67	15.10

jets are situated under the front of the furnace on full boiler pressure, and the steam supply regulated with a hand valve, which is generally full open.

The average steam consumption on 16 plants fitted with this type of stoker is about 5.25 per cent of the production, divided as follows:

Table 4.				
Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
55	2	7,054	147	0.55
40	2	8,487	80	2.96
27	3	6,382	93	3.10
30	3	4,659	58	3.20
43	1	7,463	116	3.50
49	2	3,598	86	3.80
25	3	6,073	88	4.30
65	6	6,229	127	4.34
80	2	2,212	42	4.47
50	3	6,255	135	4.93
53	3	6,046	154	5.95
13	3	5,943	108	6.25
29	4	6,915	100	6.50
72	2	5,601	130	8.90
51	4	6,316	80	9.00
46	2	7,002	148	10.00

Type C—The steam jet apparatus consists essentially of 22 jets of approximately 1-16 in. holes on

Table 5.

Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
45	5	7,557	161	2.50
44	2	3,167	93	3.40
37	3	4,376	59	3.50
15	6	6,144	61	4.20
56	2	5,754	82	4.40
7	3	6,421	51	5.40
78	2	2,848	96	17.20

$\frac{1}{2}$ in. steam pipe per furnace (that is, 44 jets per boiler on "Lancashire" boilers). The jets are situated under the furnace at the back on full boiler pressure. Steam supply regulated with a hand valve, which is generally kept very little open. The average steam consumption on seven plants fitted with this type of stoker is about 5.06 per cent of the production, divided as in Table 5.

Coking Stokers (Overfeed): Type A—The steam jet apparatus consists essentially of 37 jets of approximately 1-16 in. holes in a special casting per furnace (that is, 74 jets per boiler on "Lancashire" boilers). The jets are situated under the furnace at the back on full boiler pressure, but the steam pipe connected to the casting is much restricted at one point inside, so that the total amount of steam passing is small. The supply can also be regulated with a hand valve. The average steam consumption on four plants fitted with this type of stoker is about 2.3 per cent of the production, divided as in Table 6:

Table 6.

Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
5	2	8,059	189	1.30
62	1	7,906	150	2.25
59	5	6,037	90	2.50
26	4	4,081	52	2.70

Type B—The steam jet apparatus consists essentially of four jets, of approximately $\frac{1}{8}$ in. holes per furnace, under the furnace at the front, and two jets per furnace approximately $\frac{1}{8}$ in. holes, over the furnaces (that is, 12 jets per boiler on "Lancashire" boilers). All on full boiler pressure on $\frac{3}{4}$ in. steam pipe, and steam supply regulated with a hand valve:

Table 7.

Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
71	3	5,144	113	13.8

Type C—The steam jet apparatus consists essentially of 15 to 16 jets of 3-32 in. holes underneath the furnace at the back, 15 to 16 jets of 3-32 in. holes underneath the furnace at the front, and often one large jet, generally a $\frac{1}{2}$ in. steam pipe flattened at the end, over the top of the furnace (that is, 62 to 66 jets per boiler on "Lancashire" boilers). All jets generally on $\frac{1}{2}$ in. steam pipe on full boiler pressure, and with

steam supply regulated with a hand valve. The average steam consumption on 13 plants fitted with this type of stoker is about 8 per cent of the production, divided as follows:

Table 8.

Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
6	3	6,997	144	0.00
10	1	4,659	107	1.50
11	16	9,528	105	3.47
12	5	7,312	102	5.75
3	16	4,347	102	7.47
67	2	6,431	90	7.60
74	4	2,990	75	8.00
19	5	5,933	106	9.25
63	1	5,393	54	9.60
76	3	5,408	84	9.60
36	2	6,583	147	10.40
52	2	5,915	160	17.60
68	6	6,861	81	21.40

Type D—The steam jet apparatus consists essentially of nine jets of approximately $\frac{1}{8}$ in. holes on $\frac{1}{2}$ in. steam pipe per furnace (that is, 18 jets per boiler on "Lancashire" boilers) underneath the furnace at the back. All jets on full boiler pressure and steam supply regulated with a hand valve:

Table 9.

Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
16	3	7,737	78	7.20

Type E consists essentially of seven jets, of approximately 1-16 in. to $\frac{1}{8}$ in. holes on $\frac{3}{4}$ in. steam pipe per furnace (that is, 14 jets per boiler on "Lancashire" boilers). Jets situated under the front of the furnaces on full boiler pressure, and the steam supply regulated with a hand valve, which is generally full open.

The average steam consumption on nine plants with this type of stoker is about 7.5 per cent of the production, divided as follows:

Table 10.

Plant No.	No. of Boilers	Evaporation per Boiler per Hour, lb.	Steam Pressure	Steam Production used by the Jets Per Cent
57	2	4,463	187	3.92
24	10	6,927	137	4.52
41	4	7,702	98	5.60
61	4	4,211	74	6.02
23	13	7,401	112	6.60
9	3	5,946	114	7.02
64	9	4,955	80	7.30
34	3	7,382	145	8.00
33	15	6,533	157	11.35

Coking Stoker (Underfeed)—In considering "underfeed" coking stokers, whilst these do not use steam jets, the forced draught used must be included purely as auxiliary steam. The reason is that this type of stoker will not work with a chimney draught, where-

as the ordinary overfeed type of coking stoker and sprinkling stokers work quite well with a chimney only. Further, a certain type of underfeed stoker (Type A) has a special arrangement of steam-driven ram which used very much more steam than the ordinary drive of mechanical stokers (which can be regarded as negligible). In this case the total steam, including the forced draught, was 10.9 per cent of the production. In Type B, forced draught only, the average figure was 2.65 per cent (average of two plants).

The most striking fact is the enormous differences between the amounts of steam used by steam jets on mechanical stokers on different plants. Thus, the lowest figure was only 0.50 per cent of the production, while out of the 80 plants, 36 plants have an annual coal bill of 300 tons (equal to, say, £450 per annum, or over) solely taken up by supplying steam to the jets. It is almost incredible that individual firms of high repute should be squandering, say, 1,000 to 5,000 tons of coal per annum on steam jets alone, without the slightest system of control over this expenditure. This question of steam jets is a striking example of the necessity of scientific methods in the fire-hole, especially when there are instances of one firm using 5 per cent of the production and another firm 15 to 20 per cent with the same make of stoker.

If modern scientific methods were adopted, the average figure of 6.7 per cent of the production could be considerably reduced. The present high figure is, as usual, due to two reasons, namely, defective design of some makes of stokers and lack of proper methods of working stokers on the part of the steam users. If modern scientific methods of boiler plant control were adopted, certain types of stokers would very rarely be used on boiler plants at all, and for the remaining types the figure could be brought down to, say $3\frac{1}{2}$ per cent of the production. This latter is, therefore, an inherent defect in mechanical firing.

Based on these 80 tests, the advantages or otherwise of mechanical firing can be summarized as follows:

1. Efficiency—As boiler plants are worked today, mechanically-fired plants are actually giving inferior results to hand firing, although the difference is not great. If boiler plants were run on correct scientific lines there is no particular advantage in mechanical firing.

2. CO₂—As boiler plants are worked today, mechanically-fired plants are giving slightly better results. If boiler plants were run on correct scientific lines, mechanical firing would still give slightly better results, but the advantage is not great.

3. Life of the Boiler—There is no appreciable difference between mechanical and hand firing in this respect.

4. Amount of Steam Produced—As boiler plants are worked today, mechanically-fired plants are giving about the same results as hand firing. If boiler plants were run on correct scientific lines there would still be no advantage in mechanical firing.

5. Flexibility in Steam Output—It is a defect of mechanical firing that it will not respond to violent

fluctuations in the demand for steam as well as hand firing.

6. Flexibility in Quality of Fuel Used—It is an inherent defect in mechanical firing that it is not "flexible" from the point of view of burning all qualities of coal. It is also a defect of mechanical firing, as boiler plants are worked today, that it will not burn all grades of inferior coal as efficiently as hand firing, and the same would apply if modern scientific methods were adopted.

7. Amount of Fuel Burnt—As boiler plants are worked today, it is an advantage of mechanical firing that somewhat more coal is burnt per boiler. If modern scientific methods were adopted, there would probably be little difference.

8. Black Smoke—As boiler plants are worked today, it is an advantage of mechanical firing that less black smoke is produced. If modern scientific methods were adopted, black smoke would be abolished for both mechanical and hand firing.

9. Cost of Upkeep—This is an inherent disadvantage of mechanical firing, much greater than is generally supposed.

10. Steam Jets—As boiler plants are generally worked today, this is a most serious disadvantage of mechanical firing, and the cost of working these steam jets is enormously greater than is generally realized. If modern scientific methods were adopted, this would still be a decided disadvantage.

11. Cost of Labor—The advantages claimed for mechanical firing in this respect only apply in a comparatively few cases, that is, in large boiler plants of, say, eight "Lancashire" boilers or over.

12. Skilled Attention—More skilled attention is required as compared with hand firing, although this can hardly be called a minor disadvantage of mechanical firing.

13. Better Conditions in the Fire-hole—This is one of the chief advantages of mechanical firing, and is much greater than is usually thought, in view of labor conditions.

14. Capital Outlay, Interest and Depreciation—This is, of course, an inherent disadvantage of mechanical firing, which cannot be obviated in comparison with hand firing.

It will be seen, therefore, that a proper consideration of the advantages or otherwise of mechanical firing as applied to "Lancashire" boilers is a most complicated undertaking. It is not easy to decide whether for a given "Lancashire" boiler plant mechanical firing is advisable, and very many factors have to be taken into account. Each boiler plant has to be considered entirely on its merits, and hardly any two plants are alike. Speaking very generally, however, the advantages of mechanical firing, as applied to "Lancashire" boilers, are greatly exaggerated, and even if mechanical firing is the best for a given plant, it is still a complicated proceeding to decide which make of stoker is the best for the particular conditions.

PRODUCTION TOPICS

PRODUCTION OF PIG IRON IN THE UNITED STATES IN 1919.

The American Iron and Steel Institute has just issued special statistical bulletin No. 1, 1920, showing the production of pig iron in the United States in 1919. The statistics include all pig iron and ferro-alloys whether made in blast furnaces or in electric furnaces. Pig iron made with bituminous coal is included under coke pig iron. Pig iron made with mixed anthracite and coke is included in anthracite pig iron. Pig iron made with electricity is included in coke pig iron. Low-phosphorus pig iron, that is, iron running 0.04 in phosphorus, is included in Bessemer pig iron. Pig iron containing from 0.04 to 0.10 per cent of phosphorus is classified as Bessemer. The figures for 1913 and subsequent years include under basic iron a small quantity of charcoal iron of basic grade. In 1912 and prior years charcoal pig iron of basic quality was not included in the basic production. Nearly all the charcoal iron is classed as foundry pig iron. Ferro-silicon is included in foundry pig iron. Pig iron containing 7 per cent or over of silicon is classified as ferro-silicon. Under "all other grades" are included white and mottled iron direct castings, and miscellaneous ferro-alloys. Where not separately stated ferro-manganese and spiegeleisen are included in "all other."

The total pig iron production for 1919 was 31,015,364 gross tons, which is the lowest production since 1915, and 8,039,280 tons less than the preceeding year.

The following table shows the pig iron production by states, 1918 and 1919:

Production—Gross tons.

States	1919	1918	Increase	Per cent increase
Pennsylvania	12,276,585	15,198,271	*2,921,686	*19.22
Ohio	7,102,627	8,764,132	*1,661,505	*18.96
Indiana, Michigan	2,715,659	3,073,599	*357,940	*11.65
Illinois	2,558,213	3,440,307	*882,094	*25.64
Alabama	2,130,092	2,587,852	*457,760	*17.69
New York, New Jersey	2,070,288	2,871,118	*800,830	*27.89
Wisconsin, Minnesota	605,619	750,366	*144,747	*19.20
W. Va., Ga., Ky., Tex.	413,091	594,675	*181,584	*30.53
Virginia	319,409	513,737	*194,328	*37.82
Mo., Iowa, Colo., Mont., Wash., Oregon, Cal.	375,587	504,463	*128,876	*25.55
Maryland	244,002	373,817	*129,815	*34.73
Tennessee	190,514	369,822	*179,308	*48.48
Maine, Mass., Conn.	13,678	12,485	1,193	9.56
Total	31,015,364	39,054,644	*8,039,280	*20.58

*Decrease.

The following table shows the pig iron production by grades, 1918-1919:

Grades	1919	1918	Increase	Per cent
Basic	14,494,131	18,646,174	*4,152,043	*22.27
Bessemer and low phosphorus	9,075,934	13,024,966	*3,949,032	*23.41
Foundry and ferro-silicon	4,916,758	5,145,260	*228,502	*4.44
Malleable	1,009,649	1,117,914	*108,265	*9.74
Forge	271,286	393,932	*122,646	*31.13
Spiegeleisen	84,246	283,853	*199,607	*70.32
Ferro-manganese	185,357	333,027	*147,670	*44.34
All other	78,603	169,518	*30,915	*28.23
Total	31,015,364	39,054,644	*8,039,280	*20.58

*Decrease.

ACID BRITTLENESS.

By V. E. HILLMAN.

When steel is subjected to a pickling operation a phenomenon known as "acid brittleness" manifests itself. During the cleaning process the steel has a tendency to absorb the hydrogen gas that is liberated from the acid bath. Numerous metals possess the property, when cold, of absorbing several times their own volume of hydrogen gas. The ferrous alloys exhibit this property to a marked degree. The assimilation of the gas renders the steel extremely brittle; hence the term "acid brittleness."

Bessemer stock and high carbon stock in the "natural" condition are decidedly susceptible to the detrimental effects of such brittleness. Heat treated parts also suffer from the lack of ductility which the pickling operation confers on the metal.

A case in point is that of a large concern which was sustaining an enormous amount of breakage in a certain type of flat spring (10" long by 1/2" wide by 1/8" thick) that it manufactured. A chemical analysis of the steel showed that the metal was unassailable from the standpoint of quality. The pyrometer equipment in the heat treating department was carefully checked and in each instance the instruments showed highly accurate readings.

In brief, the steel manufacturer and the hardener were absolved from all blame for the trouble encountered. Further investigation, however, disclosed the fact that the springs were pickled for the purpose of removing the scale that formed during the hardening operation.

By a process of elimination the pickling operation proved beyond a doubt to be the primary cause of the spring breakage. The acid method of cleaning the springs was discarded and the trouble ceased immediately.

The effect of the acid brittleness could have been removed in another manner, namely, beneficial results would have been obtained by heating the springs to 400 degrees F., for the purpose of driving off the hydrogen gas that was originally absorbed. Heating "acid brittle" stock is very effective in restoring the steel to its normal condition.

As a matter of interest, the chemical analysis of the steel and heat treatment prescribed for the springs are subjoined below:

C.	.80
Mn.	.35
S.	.04
P.	.04
Hardened 1,425 degrees F.	
Drawn 900 degrees F.—Salt-peter bath.	

STEEL MERGER OF CANADIAN HOLDINGS MADE

Consolidation of nine steel, coal and transportation companies of Canada into the British Steel Corporation with a capital of \$500,000,000 has been announced. It is the largest merger of its kind in the British Empire and second only to the United States Steel Corporation.

The capital stock of the corporation will be divided as follows: Seven per cent cumulative preferred, \$50,000,000, of which \$37,000,000 is to be issued; 8 per cent cumulative preferred participating, of which \$25,000,000 is to be issued; 7 per cent non-cumulative preferred, \$150,000,000, of which \$68,000,000 is to be issued; common, \$200,000,000, of which \$77,000,000 is to be issued. Included in the consolidation are: Dominion Steel Corporation and its subsidiaries; Nova Scotia and Coal Co., Ltd., and its subsidiaries; Canada Steamship Lines, Ltd., and its subsidiaries; Canada Foundries and Forgings, Ltd., and its subsidiaries; Maritime Nail Company and its subsidiaries; Collingswood Shipbuilding Company, Ltd.; Port Arthur Shipbuilding Company, Ltd.; Halifax Shipyards, Ltd., and Davie Shipbuilding and Repairing Company, Ltd.

FOREIGN RELATIONS

THE LORRAINE IRON AND STEEL INDUSTRY.

(Trade Commissioner J. F. Butler, Paris, France)

The exploitation of the iron mines of Lorraine dates from the middle ages. Extraction is carried on in the valleys of the Fentsch and Orne Rivers, tributaries of the Moselle, located in what is known as the Thionville Basin, which forms part of a district rich in iron ore, including the Briey and Longwy iron mining basins in France, the Luxemburg basin in Luxemburg, and the iron mining region in the southeast corner of Belgium.

The first blast furnaces in Lorraine were constructed about the end of the seventeenth century. In 1870, when Lorraine was annexed by Germany, the region counted 38 small blast furnaces producing 200,000 tons of iron a year. Today there are 59 mines and 68 blast furnaces, many of which are of the most modern type, capable of producing 3,800,000 tons of iron a year. Since 1880 development in the Lorraine mining and metallurgical region has been enormous, that year marking the entrance of German capital into those industries on a large scale. Blast furnaces and steel plants sprang up in numerous localities, and this process of development continued rapidly up to and during the war. The result is that after the armistice France found itself in possession of a region of the greatest industrial richness, the importance of which is intensified when the lamentable condition of the mines and the heavy metallurgical establishments in northern and eastern France is considered.

Survey of Steel Plants Now in Lorraine.

The metallurgical establishments of Lorraine include complete groups—that is, plants consisting of blast furnaces, steel works, rolling mills, etc.—and establishments consisting only of blast furnaces. The latter have their steel works and rolling mills in the coal-mining region of the Saar, and were constructed at a period when it was economical to have the blast furnaces located near the coal supply. Modern methods of manufacture have destroyed this advantage, and the Saar blast furnaces now find themselves severely handicapped, as compared with their Lorraine competitors situated in the iron ore basin.

The steel plants of Lorraine comprise 68 blast furnaces, 27 converters, and 10 Martin furnaces, distributed among the following companies:

Aciéries de Wendel, at Hayange; 9 blast furnaces of 100 to 200 tons' capacity; 6 Thomas converters of 13 tons; 4 Martin furnaces of 30 to 45 tons; rolling mills. The production in 1913 was 519,393 tons of iron and 398,939 tons of steel.

Aciéries de Rombas, at Rombas; 8 blast furnaces of 200 to 190 tons; 4 Thomas converters of 12 tons; rolling mills. They produced 328,148 tons of iron and 261,837 tons of steel in 1913.

Aciéries Thyssen, at Hagondange; 6 blast furnaces of 300 tons; 5 Thomas converters of 30 tons; 2 Martin furnaces of 80 and 60 tons; 3 electric furnaces, 1 to 20 tons and 2 of 8 tons; rolling mills. The production in 1913 was 490,383 tons of iron and 435,000 tons of steel.

Aciéries de Rombas, at Rombas; 8 blast furnaces of 200 tons at Rombas, and 4 of 180 to 200 tons at Maizières; 6 Thomas converters of 22 tons; 4 Martin furnaces of 20 tons; rolling mills. Production in 1913 was 769,000 tons of iron and 590,000 tons of steel.

Aciéries de Knutange, at Knutange; 10 blast furnaces of 200 tons; 6 converters of 30 tons; rolling mill. Production in 1913 was 620,000 tons of iron and 468,000 tons of steel.

The De Wendel works, probably the most powerful in Europe, have always been French. The Aciéries Thyssen and the Aciéries de Rombas were entirely German. The Aciéries De Knutange were German with a certain amount

of Belgian capital. The production of these various establishments consists principally of blooms, billets, rails, and rolled steel.

Lorraine Blast Furnaces—Liquidation of Former German Interests.

Besides the plants mentioned, there are located in Lorraine the following blast furnaces: Hauts Fourneaux d'Uckange at Uckange, with 6 blast furnaces of 150 tons (1913 production, 261,000 tons of iron); Hauts Fourneaux de Thionville at Thionville, with 4 blast furnaces of 250 tons (1913 production, 316,000 tons); Hauts Fourneaux d'Ottange at Ottange, with 3 blast furnaces of 120 tons (1913 production, 144,000 tons); Hauts Fourneaux d'Andun-le-Tiche at Andun-le-Tiche, with 4 blast furnaces of 180 tons (1913 production, 200,000 tons); Hauts Fourneaux de Redange at Redange, with 3 blast furnaces of 100 tons (1913 production, 91,000 tons). Of these five companies, the first four were entirely German owned, while the fifth included about 40 per cent French capital.

The German iron and steel works of Lorraine were put under French direction as soon as possible after the armistice, and the work of liquidating them has been going on since that time. French iron and steel companies which have suffered by the war were given preference in the purchase of such properties. Payment could be effected by releasing their claims on the Government for all or part of the indemnity due them for damages caused directly by the war. Taking advantage of the occasion offered, a large number of French firms in the iron and steel industry formed associations, or "groupements," for the purchase of the Lorraine properties. The Aciéries de Rombas have been purchased for 125,000,000 francs (\$24,125,000, at par) by the Société d'Etudes et Entreprises Industrielles d'Alsace-Lorraine (also known as the Société Lorraine des Aciéries de Rombas), composed of the Compagnie des Forges et Aciéries de la Marine et d'Homécourt, Société des Aciéries de Micheville, the Compagnie des Hauts Fourneaux et Fonderies de Pont-a-Mousson, the Société des Aciéries de France, the Société de Fives-Lille, and the Société des Forges d'Allais. The Aciéries de Knutange have been purchased for 107,000,000 francs by the Participation Minière et Métallurgique d'Alsace-Lorraine (also known as the Société Métallurgique de Knutange), the principal administrator being the Société des Aciéries de Micheville. The Aciéries Thyssen (now known as the Forges de Aciéries d'Hagondange) were purchased by the Groupement des Consommateurs de Produits Métallurgiques. The purchasers of the Forges et Aciéries d'Hagondange include a number of automobile manufacturers and steel plants, among others, Renault, Panhard, Brasier, Citroën, Clément-Bayard, Delaunay-Belleville, Peugeot, Schnieder, Aciéries d'Aulnoy-la-Fère, Doremieux, Fabriques de Fer le Maubeuge, Cail, Forges de Commentry, Groupe des Fondeurs East-Centre, Forges d'Anzin, Japy Frères, Société Alsacienne de Constructions Métalliques, etc. The Hauts Fourneaux d'Andun-le-Tiche have been bought by Le Syndicat de l'Alsace. The Hauts Fourneaux d'Ottange were sold to the Aciéries de la Marine. The head offices of all the above newly constituted organizations are located in Paris.

Labor Adjustments.

Just after the armistice small-sized riots occurred in many of the plants; the workers made demands and received about everything they asked for. At the Forges et Aciéries de Hagondange for example, the newly arrived French director was obliged to agree to a demand made by the men for a premium on account of the danger suffered by the workmen from air raids during the war.—Commerce Reports.

NEWS OF THE PLANTS

The United Alloy Steel Corporation, Canton, O., is planning for the erection of an addition to its rolling mill B to develop a capacity of about 10,000 tons a month. The new installation will comprise a 12-inch continuous bar mill, to have a 16-inch roughing stand, and 12-inch finishing stand. The work will include mill gas producers, heating furnace, cooling beds, shears and other auxiliary apparatus. The plant will be electric-operated. Three new buildings will be erected, of a size 90x320 feet; 90x680 feet; and 75x300 feet; this latter work will be done by the American Bridge Company. Four new electric traveling cranes, each of 10-ton capacity, will be installed. The expansion is estimated to cost in excess of \$1,000,000, including equipment, and it is planned to have the new plant ready for service about the middle of next year.

The Illinois Steel Company, Gary, Ind., is planning for the erection of two new mills at its plant for merchant bar work, with installation to comprise a 12-inch and a 20-inch mill. Other improvements will be made at the works within the next few months, with cost of entire project estimated at about \$1,500,000.

The Pittsburgh Rolls Corporation, Pittsburgh, Pa., has arranged for the immediate construction of a new plant to cost about \$50,000. The structure will be located at Forty-first and Williams street. This organization is a successor to Seaman Sleeth Company, Forty-first street and the Allegheny Valley Railroad, known as the Phoenix Roll Mills.

The Reading Iron Company, Reading, Pa., has acquired the plant of the Susquehanna Iron Company, Columbia, Pa., and plans for extensive improvements in the works. It is proposed to inaugurate operations at the earliest moment, utilizing the plant in connection with those recently acquired at Pottstown and Birdsboro. The last noted was previously run as the Brook Puddle and Nail Mill, while the former was the property of the George B. Lessig Company. The plant at Columbia includes a total of 8 double and 15 single puddle furnaces, with an 18-inch puddle mill. It has a capacity of about 1,400 tons of material a month. In addition to the plants noted, the company is also operating works at Reading, Danville, and Emaus, Pa., giving employment to a total of about 7,000 men.

The Cleveland Steel Company, Rockefeller Building, Cleveland, O., has had plans prepared for the erection of a new plant on West One Hundred and Seventeenth street. The works will be of brick and steel type, and are estimated to cost about \$300,000, including equipment. The Arthur S. McKee Company, Rockefeller Building, is engineer on the project.

The Republic Iron & Steel Co., Niles, O., is planning for extensive additions to its local plant, known as the DeForest Works, to cost approximately \$2,000,000. The installation will comprise a number of hot and cold mills, a galvanizing plant, and a pickling plant. The new buildings will occupy property aggregating about 6½ acres, and adjoining land has been acquired for proposed future additions. The new sheet mills will be of thoroughly modern type, with water-cooled floors and water-cooled furnace fronts. The hot mills will be electrically driven in two units of four each, with one large motor for each block of mills. A plant for the recovery of copperas to cost about \$100,000, will also be installed. The new works will specialize in the production of blue, black, and galvanized sheets, and it is planned to have the extensions ready for operation before the close of the year. The company is also planning for the manufacture of highly finished sheets at a later date.

The Newton Steel Company, Newton Falls, O., has commenced production at its new plant, placing eight mills in commission. These rolling mills will be used for the manufacture of deep-drawn material to be used primarily for automobile bodies, fenders, hoods, and other metal products. It is planned to increase the complement by two more mills within the next month or so, making a total of 10 mills in operation. The company is said to have orders on hand to insure maximum production for the remainder of the year. Edward F. Clark is president.

The Martin Steel Products Company, Mansfield, O., has recently broken ground for the construction of a new one-story addition on Longview avenue, 100x300 feet, estimated to cost about \$90,000.

The Emery Steel Company, Baltimore, Md., has been reorganized with a capital of \$200,000 under the name of the Emery Steel Casting Company, with new state charter filed. The company has acquired property, about 75x275 feet on Charles street, fronting on the Baltimore & Ohio Railroad. Three brick buildings are now on this site, and these will be remodeled and improved at a cost of about \$10,000 for the new line of production. A new electric furnace will be installed.

The National Steel Rolling Company, Schuylkill Haven, Pa., is planning for the construction of a new branch plant at West Baltimore, Md. This company recently took over the plant of the Schuylkill Haven Rolling Mill, which specializes in the production of iron and steel bars. It is said that this is the only mill east of Pittsburgh manufacturing muck and reinforcing bars from scrap rail. The Baltimore plant will be of a nature of an oil and electric steel reclaiming bar mill, and will be the only plant of its kind in the eastern part of the country. As planned, the works will have an output of about 9,000 tons a year, and is estimated to cost about \$100,000, including equipment for initial installation. The company has recently acquired a tract at West Baltimore, near the lines of the Pennsylvania Railroad. Construction work will be inaugurated at an early date, and it is planned to have the plant ready for operation early in August. Headquarters of the company are at 295 Passaic street, Newark, N. J.

The Slick-Knox Steel Corporation, Wheatland, Pa., is planning for extensions and improvements at its local plant to cost about \$200,000, including equipment. It is planned to develop a capacity of about 5,000 steel automobile frames a day, and the present working force of about 2,500 men will be augmented by at least 500 more. This company was organized in June of last year, and acquired the Wheatland works from the Blaw-Knox Company. At a later date it merged the Hydraulic Drawn Forge Company with plant at Ellwood, Pa., with its business.

The Falcon Steel Company, Niles, O., operating with a capital of \$2,500,000, has inaugurated operations at its new local plant. The plant is located on the Erie and Baltimore & Ohio Railroads, with a large tract of land comprising over 100 acres. The main building is three-story, with one wing 50x620 feet, another wing, 80x650 feet, and a third wing, 70x700 feet. The works comprise annealing and galvanizing departments, electric power plant, shipping building, and a number of auxiliary structures. The entire works are electrically-operated, this equipment having been furnished by the General Electric Company. Lloyd Booth is president and treasurer, and W. W. Lewis, general superintendent. See description on page 274 of this issue.



W. R. Forrester has recently accepted the position as metallurgist with the Milton Mfg. Company. Mr. Forrester was formerly metallurgist of the Treadwell Engineering Company, Easton, Pa.

✓ ✓

W. H. Geesman has resigned as general superintendent and blast furnace manager of the Brier Hill Steel Company, Youngstown, O., having served this company for over three years during which time the two old blast furnaces were remodeled and a new furnace built, including all new ore handling machinery. Mr. Geesman's future plans are not announced.

✓ ✓

A. L. Cromlish was recently appointed general superintendent of the Farrell and Sharon works of the Carnegie Steel Company in place of O. J. Hartsuff, who assumed charge of the Edgar Thompson works of the Carnegie Steel Company. A. V. Rigby was appointed assistant general superintendent succeeding Charles Dinkey, who recently resigned.

✓ ✓

J. H. McElhinney recently resigned as assistant chief engineer of the Youngstown Sheet & Tube Co., Youngstown, O., to become chief engineer for the Columbia Steel Company, Elyria, O.

✓ ✓

C. B. Shoemaker, Jr., has returned to the Glasgow Iron Company Pottstown, Pa., as general superintendent. Mr. Shoemaker was formerly connected with this company but for a time took a position as assistant superintendent of the Roe puddling department of the Reading Iron Company.

✓ ✓

J. F. Geary, who was formerly superintendent of the Thatcher Furnace Company, Garwood, N. J., has accepted a position as assistant superintendent of the Chicago plant of the American Brake Shoe & Foundry Co.

✓ ✓

Dr. T. R. Palmer, of Cumberland, Md., formerly captain of the First Maryland Infantry in the Mexican campaign, and later major of infantry in the Regular Army, has been appointed employment manager for N. & G. Taylor Company's works at Cumberland, Md., manufacturers of steel and tin plate.

✓ ✓

J. G. Snaith has been appointed open hearth superintendent for the N. & G. Taylor Co.'s steel and tin plate works

at Cumberland, Md. He was formerly employed as foreman melter for the North works, and Duquesne works of the Carnegie Steel Company.

✓ ✓

G. E. Stoltz, general engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has been appointed engineer in charge of the steel mill section of the engineering department. After graduating from the electrical engineering course at Ohio State University in 1909, Mr. Stoltz entered the apprenticeship course of this company after which he became engaged in steel mill work. He therefore, is familiar with problems of steel mill electrification on account of his connections with this industry during its greatest period of development.

✓ ✓

G. W. Smead has resigned as master mechanic at the Berger Manufacturing Company, Canton, O., to become superintendent of the new Louisville Sheet Steel Company's plant being erected at Louisville, Ky.

✓ ✓

R. C. Garlick, Cleveland district sales manager for the Sharon Steel Hoop Company Sharon, Pa., for the past year, has resigned to become affiliated with the Columbia Steel Company, Elyria, O., as assistant to its vice president and manager, C. E. Lozier.

✓ ✓

T. P. Draper, general manager of the Sharon Steel Hoop Company, Sharon, Pa., has recently been elected vice president and director of that company.

✓ ✓

J. P. Roe is now connected with the Reading Iron Company. His activities will be largely connected with the development of the Roe puddling process. Mr. Roe was formerly general superintendent of the Glasgow Iron Company, Pottstown, Pa.

✓ ✓

C. E. Leshner, who has been director of the bureau of coal economics of the National Coal Association, Washington, and prior to that compiled the weekly coal and coke statistics for the federal geological survey, will become connected with the editorial department of the Coal Age.

✓ ✓

W. T. Brangham has been appointed assistant general manager of sales for the Falcon Steel Company, Niles, O. A description of the new sheet mill of this company appears in this issue of THE BLAST FURNACE AND STEEL PLANT.



Roy M. Wolvin has recently been elected president of the Dominion Steel Corporation, Ltd., Sydney, N. S., succeeding Mark Workman. Mr. Workman will, however, continue as chairman of the board of directors. Mr. Wolvin was born at St. Clair, Mich., January 21, 1880. In 1901 he became general manager of the Great Lakes & St. Lawrence Transportation Company, and the Standard Steamship Company. In 1910 he became president of the Standard Shipping Company, Winnipeg, Man., the Duluth Shipping Company, Duluth, and the Central Shipping Company, Chicago. Since this time he has held important and responsible positions with large shipping interests. In 1919 Mr. Wolvin was elected a director of the Dominion Steel Corporation.

V V

Harry Bocht, formerly assistant superintendent of blast furnaces at the Sharon and Farrell works of the Carnegie Steel Company, has been made superintendent of blast furnaces, succeeding A. L. Cromlish, recently promoted to the position of superintendent of those plants.

V V

Dwight R. Robinson has been elected president of the Westinghouse, Church, Kerr & Co., Inc., 37 Wall street, New York City, engineers and constructors, whose recent merger with Dwight P. Robinson & Co., Inc., has been ratified and declared operative. Mr. Robinson has been in the engineering and construction business for about 25 years, for some time as a member of the firm of Stone & Webster. He retired from that partnership July 1, 1918, retiring also as president of the Stone & Webster Engineering Corporation, an office held by him since 1908. In the spring of 1917, when the American International Shipbuilding Corporation was formed as a subsidiary of the American International Company, to build and operate the government fabricating shipyard at Hog Island, Philadelphia, he was elected president. In March, 1918, he resigned.

V V

Joseph Bean, formerly mill superintendent of the McDonald plant of the Carnegie Steel Company, is now connected with the Trumbull Steel Company, Warren, O. Mr. Bean was connected with the McDonald plant since it started operations.

V V

George A. Laub is now superintendent of the Sligo Iron & Steel Co., Connellsville, Pa. Mr. Laub was formerly connected with the American Car & Foundry Company, Berwick, Pa.

V V

Hollinshead N. Taylor, N. & G. Taylor Co., manufacturer

of forging steel, Philadelphia, president Drop Forge Supply Association, has appointed Stuart Hazlewood, Midvale Steel & Ordnance Corporation, and George Satterthwaite, Tacony Steel Company, to represent the association upon a committee in charge of the arrangements for the coming joint meeting of this association with the American Drop Forge Association at the Marlborough-Blenheim Hotel, Atlantic City, June 17, 18 and 19.

V V

C. B. Cushwa has been appointed works manager of the Brier Hill Steel Company and R. J. Mulally assistant works manager. Mr. Cushwa succeeds William H. Warren, resigned. Clyde Maxwell has been appointed plate mill superintendent, succeeding R. J. Mulally.

V V

Harry C. Davis, formerly superintendent of the Thomas and Empire hot mills of the Brier Hill Steel Company, at Niles O., will be operating manager of the plant of the Ashtabula Steel Co. Ashtabula, O. The new plant is to include eight hot mills for making black and galvanized sheets. The contract for the building has been let to the McClintic-Marshall Company. The General Electric Company will install the electrical equipment, and the Fuller Engineering Company will install a pulverized coal system. The sheet and pair furnaces will be of the combination type and the annealers of the under-fired type, all of which are designed especially for powdered coal fuel.

V V

Harry L. Brinker, formerly assistant superintendent of blast furnaces at the Ohio works of the Carnegie Steel Company, is now blast furnace superintendent of the Brier Hill Steel Company, Youngstown, O. Mr. Brinker was connected with the Carnegie Steel Company for 25 years, starting as an assistant chemist.

V V

W. H. Eshelman, formerly superintendent of the 84-in. and 132-in. plate mill of the Brier Hill Steel Company, is now assistant superintendent of the plant of the Bethlehem Steel Company, at Sparrows Point, Md.

V V

E. J. Buegler, formerly consulting engineer of the Westinghouse, Church, Kerr Company, has been elected a vice president of the Foundation Company and will be in charge of engineering. Joseph H. O'Brien, formerly vice president and chief engineer of the Central Construction Corporation, and before that for 15 years with the Westinghouse, Church, Kerr Company, has been appointed chief engineer of the Foundation Company.

INDUSTRIAL RELATIONS

SAFETY METHODS OF THE UNITED STATES STEEL CORPORATION.

The following is the second part of the paper which was commenced in the last issue of THE BLAST FURNACE AND STEEL PLANT. The paper was originally read before the Engineers Society of Western Pennsylvania.

The work in sanitation has been organized in a manner almost identical with the safety organization, except that the sanitation committee is chosen from the presidents of the subsidiary companies with an officer of the United States Steel Corporation as one of its members. This committee administers the work through a sub-committee composed largely of technical representatives from each of the subsidiary companies.

In sanitation, many improvements have been made in the proper investigation and observation of water-supply and distribution to the employes. All sources of drinking water are analyzed periodically and great care is taken to prevent possible pollution by surface water or otherwise. The most modern sanitary methods are employed in the cooling and distributing of the water, including the installation of sanitary drinking fountains, and the common drinking cup has been practically eliminated.

The committee has prepared specifications covering general sanitary requirements and these are followed by the subsidiary companies when installations are made. An important requirement in these specifications is that no wash-basins shall be installed. Facilities for washing the face and hands shall be such that employees must necessarily wash from the flowing stream. This may seem radical, but we think it important, in order to avoid any possible danger of spreading disease. Good toilet facilities have been installed at all plants and mines—these facilities usually including shower baths. A number of swimming pools have been built for the general use of the people in the mining towns.

In Alabama, where one of our mining companies conducts its operations, the conditions are favorable to mosquito breeding. This company is doing much to prevent the spread of malarial fever. Streets and alleys are properly drained; pools and lowlands are drained or filled in, where practicable; otherwise they are covered with crude petroleum. All known methods of fighting the mosquito are used. By these methods the number of cases of malarial fever has been greatly reduced, and the comfort of the people living in the camps has been increased.

Metal garbage cans equipped with tight fitting covers are placed at the rear of each house in the mining camps, and at convenient places throughout the mills. Garbage and other waste materials are collected periodically and burned.

Some of the subjects of which the sanitation committee is now making a study are, occupational diseases, mine sanitation, proper ventilation in plants and company houses, provisions for proper heating and lighting systems in plants, provisions for regulation of milk supply, dust removal at plants, including roadways.

Plant Restaurants.

The success attending the operation of plant restaurants already installed by the subsidiary companies, and the benefits resulting therefrom, have encouraged many more installations of like character in other plants of the subsidiary companies. In addition to giving the employes an opportunity to secure good, wholesome food at moderate cost, there are other benefits more diversified in character than might appear at first thought. These can best be summed up by quoting from an article of one of the officials of a subsidiary company, which has given considerable attention to the installation of restaurants within its plants:

"When laboring overtime on break-down or emergency work the employe can secure a full meal at his usual dinner hour. Workers in exposed situations during severe weather can be refreshed by a portion of hot soup or coffee.

"When exhausted by heat and physical exertion in warm weather, a refreshing draught obtained when most needed frequently enables an employe to return to work with renewed vigor when otherwise he would be incapable of useful exertion for a considerable time. The aromatic bottled drinks furnished at practically all of our restaurants seem to supply the necessary stimulation to overcome abdominal cramp among workers laboring in heated positions, the cramp being frequently superinduced by injudicious drinking of water when one is suffering from stomach derangement or careless exposure of the person to strong currents of air.

"The burden of the housewife in the daily preparation of the dinner bucket, following the serving of an early morning meal is eliminated. Where father and son have both to be provided for, as is often the case, the burden is by no means a light one.

"When the wife is ailing or away from home, or sickness occurs among the little ones, the breadwinner may have to undertake the unfamiliar role of household cook—sometimes with disastrous results to his own internal well-being, not to mention that of his family. Where a mill restaurant is available, a half-hour earlier start from the house secures him an inviting breakfast at a moderate cost.

"An equally important consideration is the selection of the contents of the dinner bucket. The most desirable forms of food are not always adapted to packing, nor will they retain their freshness and palatability after standing for several hours in unsuitable temperature, as is often their fate. It is not uncommon in rolling mills to see a large proportion of the contents thrown away because of its unpalatable or uninviting condition. As a further argument to prove the inadequacy of the packed lunch when put up by inexperienced housekeepers it may be stated that, not to speak of the questionable assimilative value of certain articles and combinations of food frequently found therein, fairly numerous cases occur where men, after consuming the contents during the noon period, visit the restaurant in the afternoon to purchase a 10 or 15-cent meal.

"For the unmarried men lodging in rooms—and especially those who do not or cannot obtain their meals at a boarding house—the higher prices prevailing in public restaurants is a condition not always easy for the young man to meet. Here again the problem of the dinner bucket has to be confronted, with the added difficulty however, of getting the bucket filled with the things he likes, or that seem to best meet his particular requirements. The unmarried man and the foreign day laborer are usually good patrons of that section of the mill restaurant counter where such tasty items as fruit, cake or dessert provide a welcome addition to the somewhat monotonous fare of the boarding house."

In addition to numerous restaurants which have been installed in the plants of various companies where food is served, considerable attention has been given to rest rooms and dining-rooms of various descriptions, so that employes may retire to a clean and sanitary place remote from the operating departments, to eat their lunch.

Musical Organizations.

Often considerable musical ability is displayed by the workmen at the various plants, and wherever sufficient material is found, brass bands are organized and male chorus singing is encouraged, the equipment and maintenance of these organizations being mainly at the expense of the company.

Some Pointers on By-Product Coke Oven Operations

BY-PRODUCT COKE AND BY-PRODUCT OF COAL

(Continued From Page 287)

The volume of gas evolved from the coal in the coking operation exceeds the requirements for heating the ovens. This surplus varies from 4,000 to 6,000 cu. ft. per ton of coal coked, depending upon the character of the coal and the efficiency of the oven heating system. Its heating value will run from 525 to 600 Btu. per cu. ft. When the gas coming from the ovens is separated so that only the leaner gas is burned in the flues of the ovens, the heat value of the surplus or richer portion of gas is usually about 600 Btu. or more per cu. ft.

The purpose for which this surplus gas is used is largely dependent upon the location of the coke ovens. Large quantities are being used by steel mills in open hearth furnaces, soaking pits, etc. When burned in open hearth furnaces it is general practice to increase the luminosity of the flame by burning a certain portion of tar along with the gas.

Many plants located in the vicinity of the large cities are able to sell much of their surplus gas for domestic purposes or to other industrial plants.

Coke oven gas is used quite extensively in Europe in internal combustion engines. This field has not been developed in this country up to the present time. However, the American Iron & Steel Mfg. Co., at Lebanon, Pa., in 1907 installed a gas engine, using coke oven gas from the Semet-Solvay ovens there. A larger installation, receiving gas from the same coke ovens, was installed at the Cornwall ore banks in 1910. Both plants generate electric power and have been very successful. It is unnecessary to say that gas for use in internal combustion engines must be very clean.

The demand for coke oven gas may be sufficiently great in some instances to make the gas a more important product than the coke. In such cases the plant would actually be a by-product gas plant, meaning that the principal factor in operation was the production of gas. Such plants are equipped with gas producers, so that in periods of great demand, the oven gas used to heat the ovens may be partially or wholly replaced with producer gas, leaving a larger volume of oven gas available for delivery to domestic consumers.

This field will probably be developed to a greater extent in the future, particularly in districts supplied with natural gas, the supply of which is diminishing each year.

Many large cities, such as Boston Providence, Newark, Jersey City, Indianapolis, Buffalo, Milwaukee, St. Louis, St. Paul, Chicago, Cleveland, and Detroit, in addition to many smaller cities and towns, receive a part of their gas from by-product coke ovens.

Future Development.

The by-product coke oven is destined to play an important part in industry in the future. The market for by-products will be such that it will be unprofitable to produce coke in a non-recovery oven. The demand for the elimination or reduction of smoke in thickly populated centers is becoming more urgent each year, and moreover the presence of smoke indicates that coal is not being burned efficiently. Since it is practically impossible to avoid entirely the production of smoke in burning soft coal, the only remedy is the use of a coke. The small sizes of coke can be used in small power plants and the large sizes in private homes. The annual production of anthracite has probably reached its maximum and its consumption will be limited to the districts near which it is mined. The logical substitute is coke.

The increase in the production of by-product coke will

make available larger volumes of gas for cooking and other domestic uses, as well as for industrial purposes.

The supply of by-products, such as benzol for motor fuel, and sulphate for fertilizers will be greatly increased. The increase in population, particularly in the large cities, demands increased crops. The acreage available for agriculture cannot be increased and the only alternative is increased productivity, which means more fertilizer.

The Work of the Semet-Solvay Company.

The Semet-Solvay Company was one of the pioneers in the introduction of the by-product coke oven into this country. It has been a leader in the developments that made possible the present high efficiencies in oven operation and by-product recovery. The plants under its control have grown in number until 21 by-product coke oven plants are under its control or associated with it.

It has also done much to develop the utilization of the by-products. Previous to the outbreak of the European war it was practically the sole producer of benzol products in America. In 1900 it began the synthetic production of phenol from benzol, and picric acid from phenol.

It has also been closely associated with the dye industry, many of its products being the raw materials in the manufacture of colors and dyes.

The number of its products has increased to 35 and are used for many different purposes.

A large part of the coal used in some of the Semet-Solvay plants is produced at its own mines. It is, therefore, the only commercial company in the United States engaged in every phase of the production of finished chemical products from the raw coal.

WORLD'S PRODUCTION OF CHROMITE IN 1918.

In view of the record-breaking production of chromite in the United States in 1918, reported by the United States Geological Survey, Department of the Interior, it is of interest to note the part it played in the world's output for that year. The approximate output in round numbers for each country is expressed below in metric tons.

World's Production of Chromite in 1918.

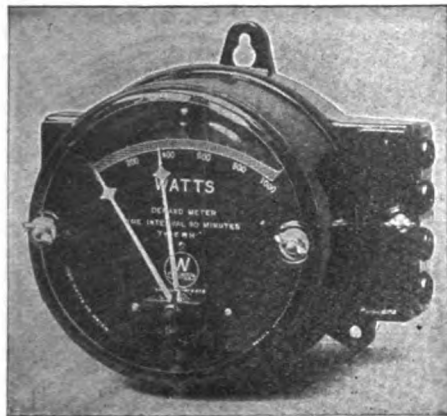
United States	84,000
Canada	20,000
Cuba	9,000
Guatemala	1,200
Brazil	18,000
British South Africa.....	28,000
Turkey (Asia Minor).....	14,000
Greece	10,000
Austria-Hungary	500
Russia	16,000
India	20,000
Australia	800
New Caledonia	26,000
Japan	8,000

The Massachusetts Iron & Steel Co., Danvers, Mass., recently organized with a capital of \$500,000, has taken over the property of the Danvers Iron Works and the Sylvester Company. These two plants will be merged. Improvements and additions are now under way to accommodate the new business, and it is proposed to develop a capacity of 50 tons of steel per day, as well as a large quantity of spikes, nuts, and kindred specialties. Carl P. Dennett is president of the new corporation.

The National Tube Company, Lorain, O., is planning for the construction of two new lap mills at its local plant. It is proposed to inaugurate work at once. At the present time this plant comprises five such mills.

WITH THE EQUIPMENT MANUFACTURERS

NEW TYPE OF THERMAL DEMAND METER.



Thermal demand meter

demand meters for alternating current circuits and ampere demand meters for alternating and direct current circuits.

The watt demand meter can be used to measure the watt demand in all types of alternating current circuits where it is desired to measure the load with an indicating type of demand instrument. The ampere demand meter is applicable to installations where it is desired to measure the current demand; this type of ampere demand meter is especially applicable in determining the average current in steel mill and railway work where a motor load varies through a wide range within a very short time.

The moving element of the instrument consists of a shaft connected to two bi-metallic spiral springs. The springs are attached to the shaft at their inner ends, and to a cylindrical case at their outer ends. The springs are wound in opposite directions so that an equal change in the temperature of both springs does not produce any rotation of the shaft. The instrument is, therefore, independent of atmospheric temperature changes. However, if one spring is raised to a higher temperature than the other, it will deflect through a greater angle than the other, and the shaft will move through an angle which is proportional to the difference in temperature of the two bi-metallic springs. Each of the cylindrical cases mentioned above contains a heating element which is connected to the electrical circuit in such a way that one spiral spring is raised to a higher temperature than the other, which results in the shaft deflecting through an angle proportional to the load on the meter.

In the wattmeter, the difference in the temperature of the two spiral springs, and hence the deflection of the shaft is made proportional to the watts by causing the load current to pass through the heating elements in such a way that in one heater it is additive to a current which is proportional to the voltage, and subtractive from the same current in the other heating element. In other words, if E is a current which is proportional to the line voltage, and I is the load current in each element, then the total current in one heating element will be $E + I$ and the other $E - I$. The losses, and hence the heating in the elements, are proportional to the squares of these currents, and it is readily seen that the difference in the heating is the difference between the squares of $(E + I)$ and $(E - I)$ which is proportional to the product of EI or watts. Due to the thermal storage of the

cylindrical cases surrounding the bi-metallic springs, the wattmeter does not respond instantly to a change in load, but always indicates the logarithmic average load for the time period immediately preceding the instant of observation. The thermal storage capacity of the cases is so designed that the wattmeter gives a deflection equal to 90 per cent of

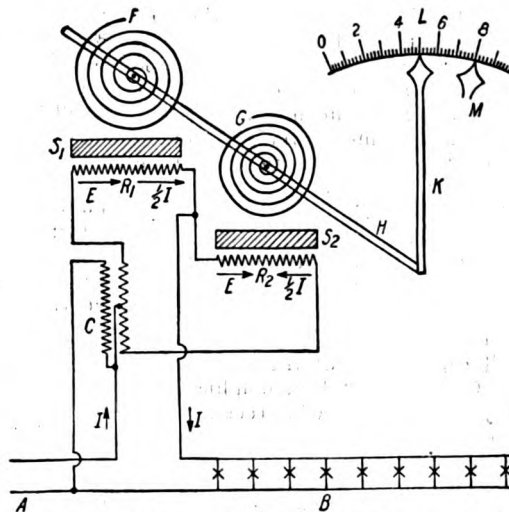


Diagram of thermal demand meter

the final deflection in the rated time interval of the meter. This means that a 30-minute meter will give an indication equal to 90 per cent of final indication in 30 minutes, 99 per cent at end of 60 minutes, 99.9 per cent at the end of 90 minutes, etc.

The wattmeter has two pointers, one of which, the indicating pointer, is fixed to the shaft, while the other, the maximum demand pointer, is free to remain in the maximum position in which it is placed by the indicating pointer. By observing the indicating pointer the logarithmic demand for the period immediately preceding the instant of observation can be determined. The maximum demand pointer can be reset at any time without removing the cover from the instrument.

The ammeter uses a different scheme of connecting the heating elements to the circuit which results in a deflection of the pointer which is approximately proportional to the square of the current. However, the mechanical design of the ammeter and wattmeter is practically the same. The mechanical design of the meter is very rugged so that the meter will stand an unusual amount of rough handling without interfering with the calibration. The spiral springs are made of bimetallic strip 7/16 inch wide, thus giving a rugged spring with a high torque. The polyphase meter is practically the same size as the single phase, the only difference being that the polyphase meter has a terminal chamber at each side of the case while the single phase meter has only one terminal chamber which is located at the bottom of the case.

The subject of the thermal storage demand meter is treated in detail in the October, 1915, and the February, 1918, issues of the "Transactions A. I. E. E.," by P. M. Lincoln, and also in the October, 1919, issue of THE BLAST FURNACE AND STEEL PLANT.

TRADE NOTES

Charles C. Phelps recently became associated with the Uehling Instrument Company, 71 Broadway, New York, combustion engineers, as well as manufacturers of CO₂ recording equipment and other fuel economy apparatus. He is devoting most of his attention to research work in connection with the efficient combustion of fuel oil in boiler furnaces. It is estimated that nearly \$100,000,000 is wasted unnecessarily every year, due to improper methods of burning fuel oil, which fact shows the importance of this field of investigation. Mr. Phelps graduated from Stevens Institute of Technology with the degree of mechanical engineer and has since spent several years studying power plant problems. For five years of this period he was connected with the Ingersoll-Rand Co., manufacturers of power plant equipment and pneumatic machinery. Mr. Phelps is an associate member of the American Society of Mechanical Engineers.

C. C. McDermott has assumed charge of the Chicago office of the Brown Instrument Company, of Philadelphia, succeeding J. W. Lazear, who recently resigned to take up other work in New York. Mr. McDermott has been transferred from the Philadelphia office where he has been district manager for some time. Mr. McDermott has studied pyrometers, thermometers, pressure gauges and other Brown instruments right in the Philadelphia laboratories of the Brown Instrument Company.

The Combustion Engineering Corporation, with offices at 11 Broadway, New York City, manufacturers of Type E stokers, Coxe stokers, Type K stokers Grieve grates and other boiler room equipment relating to combustion engineering, announces with considerable regret the resignation of its vice president, in charge of sales, Mr. E. P. Moritz. Mr. Moritz had been ill for some time previous to his resignation and owing to his continued ill health it has been necessary for him to retire from active business for some time. No successor to Mr. Moritz has been named by the company up to date.

The Homestead Valve Mfg. Company, of Homestead, Pa., announces the removal of its New York office to 242 Lafayette street, New York City. The New York office is in charge of P. L. Rhodes, who has with him William Gormly, John Gormly, George Nagle, C. A. Tyler and W. B. Goering.

The Electric Furnace Construction Co., Philadelphia advise the following new orders for "Greaves-Etchells" electric furnaces: Wayne Steel & Iron Co., Groghan, N. Y., 1-ton furnace; Stora Kopparbergs Bergslags Aktiebolaget, Domnavet, Sweden, one 20-ton for steel ingots; Soc. Metallurgique de la Loire,

St. Etienne, France, two 10-ton for steel ingots; S. A. C. Electriques de Charleroi, Belgium, one ½-ton for castings; Carlisle Steel Company, Sheffield, one ½-ton for tool steel; Sproat Marley & Co., Newcastle, England, one 1-ton for steel castings. As indicative of the recent developments in the field for electric furnaces, it is interesting to note that the Metallurgical section of the Sheffield University, England, have decided to install a half-ton "Greaves-Etchells" furnace for experimental work on tool steels and on iron melting.

Frey, Brassert & Co., engineers, Chicago, have completed erection of a plant for the Grip Nut Company. This plant is located at Fifty-ninth and Western avenue, Chicago, with excellent switching facilities, being on the Chicago outer belt line. The building is of modern steel and brick construction 100 ft. by 300 ft. The main building is 50 ft. by 300 ft., being of brick and steel construction with cement tile roof. This building is served by a 10-ton 46-ft. span Whiting crane. This crane operates through the entire length of building and also over a runway extending 200 ft. beyond the building. The saw-tooth section of building is 50 ft. by 300 ft., divided into two 25-ft. span saw-tooth sections. The annex of building is 40 ft. by 70 ft., two stories high; the first story will be used as a machine shop and the second story for general offices for the company. The boiler house equipment consists of two Kewanee boilers which furnished steam for the annex and also for a hot air system in the saw-tooth section. Particular attention has been paid to lighting, heating and ventilation.

Mechanical consulting engineering offices have been opened at 226 Superior avenue, West, Cleveland, O., by Clifford H. Peters. Until recently, Mr. Peters was captain, U. S. A., attached to the engineering division; Ordnance Department. Mr. Peters' engineering practice includes the design and construction of various types of automatic and semi-automatic machines, as well as plant layouts, production systems and similar engineering service.

The Morse Chain Company, Ithaca, N. Y., have moved their offices from Greensboro, N. C. to Charlotte, N. C., 404 Commercial Bank Building. Mr. George W. Pritchett, southeastern manager, has found this change advisable owing to the great increase in use of Morse silent chains throughout every branch of textile industry, which has been having such a phenomenal growth, necessitating the building of new mills and increasing the capacity of all the southern mills, large and commodious new quarters have been secured where they will have a complete exhibit of chain drives in operating order.

Westinghouse Opens Largest Employees Cafeteria.

On April 6, when the largest industrial eating place in the world was officially opened by the Westinghouse Electric & Manufacturing Co., at East Pittsburgh,

Pa., evidence was given of what the larger manufacturers of today are doing in the way of providing for the comforts of their employees. This new cafeteria which is a three-story reinforced concrete and brick building, 236 ft. by 100 ft., has a seating capacity on the first two floors alone of nearly 2600 persons. In addition, on the third floor there is a dining room with a capacity of 500 and an auditorium with a seating capacity of 1,000.

One of the main features is the fact that there are no steps in the main part of the building. Gradual inclines or ramps are used exclusively in order to facilitate moving the diners from floor to floor.

The first and second floors are devoted to cafeteria service, a section being reserved for women employees of the company. By means of the auditorium on the third floor a suitable meeting place for the various employees associations and organizations is obtained. The auditorium is equipped with a stage 20 ft. by 18 ft., complete with foot-lights, stage settings, and a convenient dressing room. A motor-driven motion picture machine of the very latest type is installed in an asbestos booth in the rear of the auditorium, and will be used in connection with various lectures, entertainments and other gatherings held under the auspices of the company, or some of its employees organizations.

The cafeteria is equipped with the most modern labor saving conveniences that are obtainable. On the first and second floors are eight service counters, 16 coffee urns, milk freezers with a capacity of 40 gallons each, and sanitary drinking fountains.

Soiled dishes are carried from the first and third floors to the second floor where two large motor-driven dish washers are installed, which wash and dry the dishes.

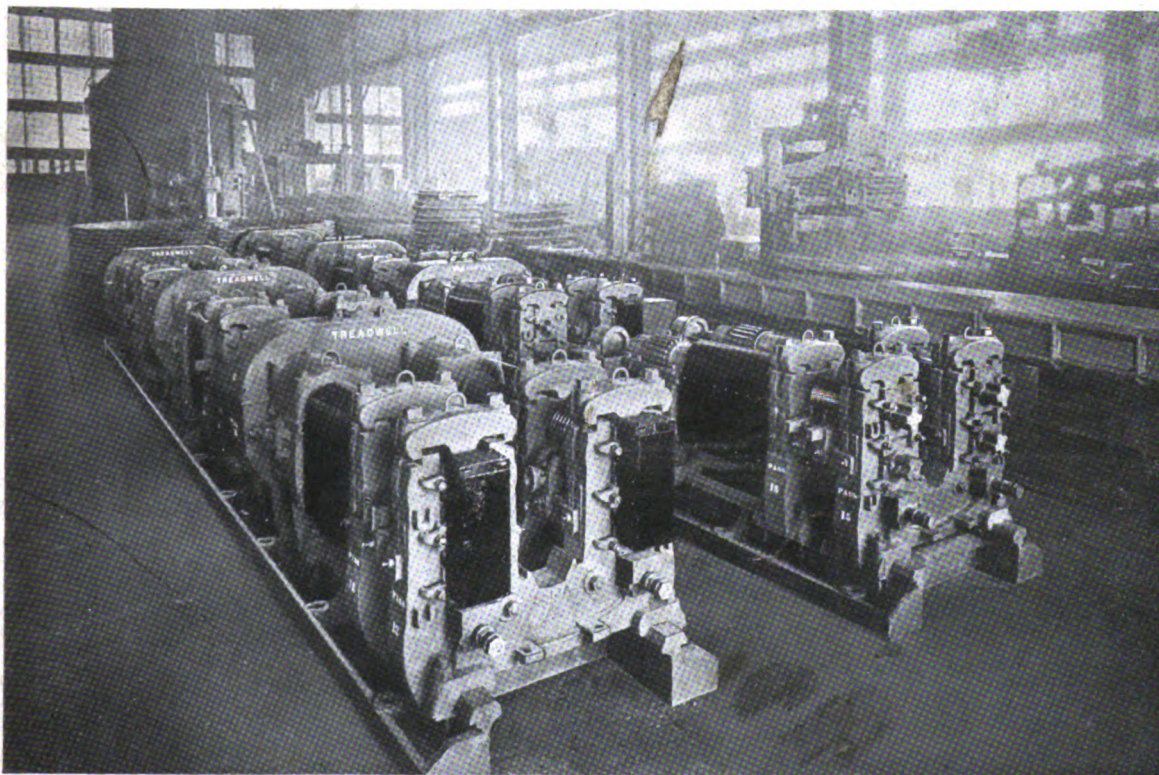
A portion of the first floor adjacent to the cafeteria is fitted up with a motor-driven washing machine, mangles, steam dryer for the purpose of washing and drying linens, motor-driven ice cream freezer with a capacity of 10 gallons and an ice-making machine with a capacity of 2000 pounds every 12 hours. The ice manufactured is to be used for the purpose of packing ice cream, cooling butter, making iced tea, lemonade, etc.

All food will be cooked on the third floor and will be supplied to the cafeterias by sub-conveyors. The kitchen is equipped with every possible method of convenience, including large gas ranges as well as double unit combination gas and coal ranges, steam meat roaster, steam service table, potato peeler which peels 40 pounds of potatoes in less than two minutes, bread cutter, potato masher, all motor driven, and a coffee urn for dining-room service. Two steam-heated kettles with a capacity of 60 gallons each are used to make soup. Also, electrically-heated pie baker with a capacity of 65 pies in 15 to 20 minutes, one large refrigerator for cooling meats and two smaller ones to cool vegetables and dairy products.

Member of the Audit Bureau of Circulation.

The Blast Furnace *and* Steel Plant

Pittsburgh, May, 1920.



10" Wire Rod Mill built for the Black Steel & Wire Co., Kansas City, Mo., on our Erection Floor

MODERN
ROLLING MILL
MACHINERY

and

STEEL
MILL
EQUIPMENT

TREADWELL ENGINEERING COMPANY
EASTON, PA., U.S.A.